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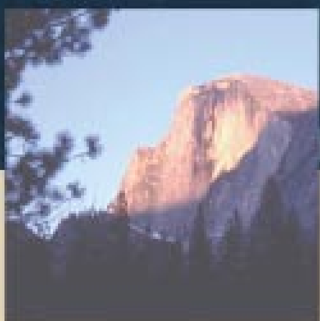

Environmental Protection Indicators for California

California Environmental Protection Agency – California Resources Agency

Cover photograph—Big Sur

Insets, top—Half Dome at Sunset–Yosemite Valley, Daryn Dodge

Middle—Joshua Tree National Park

Bottom—Sacramento skyline above Vic Fazio Yolo Wildlife Area, Daryn Dodge

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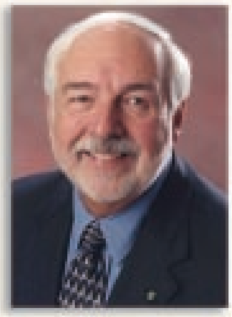

From the Agency Secretaries

We are fortunate to live in a state with rich scenic beauty and abundant natural resources. Since the Gold Rush, California's diverse environmental assets have drawn people to the state and driven the development of the now-fifth largest economy in the world. However, the stresses of continuing population growth and economic expansion challenge our ability to protect public health and environmental quality. Meeting these challenges will require new approaches that rely on better information about our environment.

This report, *Environmental Protection Indicators for California,* presents the foundation for measuring the state's environmental quality in terms relevant to both human and ecosystem heath. The indicators in this report provide objective, scientific information by which to assess California's environment and to guide our efforts in sustaining it for future generations.

This report represents an 18-month effort of the California Environmental Protection Agency and the California Resources Agency – two cabinet-level agencies with different, yet complementary, missions to protect the environment. Other state entities, including the Department of Health Services, as well as various other stakeholders, collaborated on its development. Consequently, we have not only established an environmental indicator system, but also have built and strengthened partnerships that will help us achieve our shared goals.

This report is just the beginning of an ongoing process to integrate and use information about the environment in a more meaningful way. In developing the initial set of indicators, we have gained a better awareness of what we know, and of what we need to know, about our environment. In the coming years, the Environmental Protection Indicators for California, or EPIC, Project will work with the Resources Agency's Legacy Project and other related assessment efforts within state government to enhance our capacity to report on California's environment and natural resources and to frame new approaches to solving environmental problems.

We hope this report provides you useful information about California's environment. We are committed to assessing and updating these indicators to ensure that our efforts to protect California's environment are worthy of you, the people of California.

Winston H. Hickox Secretary for Environmental Protection	Mary D. Nichols Secretary for Resources

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ENVIRONMENTAL PROTECTION INDICATORS FOR CALIFORNIA

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ACKNOWLEDGEMENT

As the lead agency responsible for the *Environmental Protection Indicators for California Project,* the Office of Environmental Health Hazard Assessment is pleased to present the project's first report. This report is the product of a year and a half effort to establish a process for developing environmental indicators, and to apply this process to generate an initial set of indicators.

OEHHA wishes to acknowledge the following individuals and organizations for their valuable contribution to the preparation of this report:

- The EPIC External Advisory Group, consisting of representatives from academia, environmental/public interest organizations, local government, and the regulated community.
- The EPIC Interagency Advisory Group, consisting of policy-level representatives from various state agencies.
- EPIC Project staff from Cal/EPA and its boards and departments, from the Resources Agency, from the Department of Health Services, and from the California Research Bureau.
- OEHHA's core EPIC Project staff: Daryn Dodge, Lubow Jowa, Linda Mazur, Carmen Milanes, David Siegel and Barbara Washburn.
- OEHHA's consultants, Gil Bergquist of the Florida State University Program and Policy, Program for Environmental Policy and Planning Systems, and Clint Whitney, R&G Associates.

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Environmental Protection Indicators for California

EPIC

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Executive Summary

Introduction

California is strongly committed to protecting its rich and diverse environmental resources. Over the years, substantial efforts have been devoted toward this end. In many instances, the state has been recognized as a national and international leader in developing environmental standards, yet there are very few meaningful, objective measures with which to assess the environmental impacts of these standards.

The Environmental Protection Indicators for California (EPIC) Project was created to support a commitment to use measurable results in judging the effectiveness of the state's efforts directed at environmental protection. This report presents the work products of the first year of the EPIC Project, which was devoted to establishing the framework for an environmental indicator system. The framework consists of guidelines and criteria for identifying and selecting indicators, the environmental issues that are important for California to track, and an initial set of indicators. The EPIC Project will continually evaluate, improve and expand this initial set of indicators to ensure that it provides meaningful information for better understanding the state of California's environment, and for planning and decision-making.

Environmental indicators are scientifically based measures that convey complex information on environmental status and trends in an easily understood format. They communicate information to the public as well as improve our understanding of the environment. Environmental indicator systems have been used around the world and in the United States at the federal and state level, and by local communities.

The Initial Set of Environmental Indicators

Environmental indicators were developed for significant environmental issues in the following broad areas:

- Air quality
- Water
- Land, waste and materials management
- Pesticides
- Transboundary issues
- Environmental exposure impacts upon human health
- Ecosystem health

An additional set of "background indicators" was also developed. These indicators reflect trends in certain demographic, economic, human health and other parameters that can provide a meaningful context with which to interpret some of the environmental indicators. A complete list of all the indicators can be found at the end of this summary.

The process by which issues were identified, and indicators selected, is described in Chapter 2. The initial focus of the EPIC Project is on indicators that:

- reflect issues affecting California, or global or transboundary issues of interest to the state;
- relate to Cal/EPA's mission to protect, restore, and enhance the environment, and to areas where this mission overlaps with those of the Resources Agency and the Department of Health Services; and,
- measure human-induced pressures on the environment, ambient environmental conditions, or effects on human or ecological health.

Indicator selection relies on primary criteria designed to ensure that the indicator is based on data collected using scientifically acceptable methods, closely represents the issue, is sufficiently sensitive to distinguish change, and provides a meaningful basis for policy decisions. A set of "secondary criteria" highlight additional desirable attributes of an environmental indicator: ability to provide early warning, comparability to indicators in other systems, cost-effectiveness, and the availability of a point of reference or a benchmark value.

The indicators are classified based on the availability of data. Type I and Type II indicators are supported by ongoing, systematic monitoring or data collection. For Type I indicators, adequate data are available to present a status or trend graphically. Type II indicators require further data collection, analysis or management. Type III indicators are conceptual (sometimes based on a one-time study), and reveal areas lacking systematic data collection.

Findings

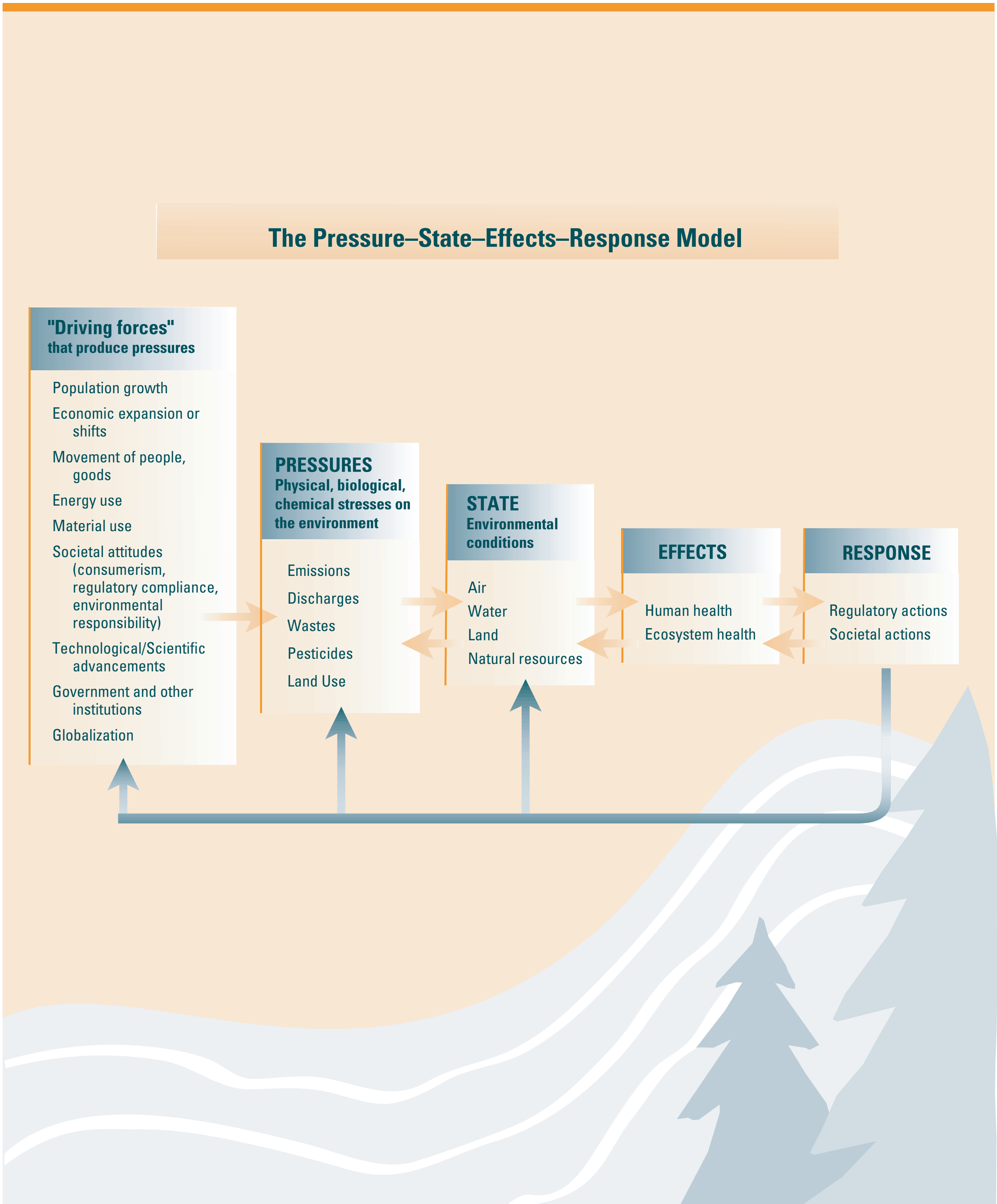
This report takes an important first step in presenting a collection of environmental indicators derived from various sources, spanning a wide range of significant environmental issues confronting California. The indicators, individually and collectively, can provide better understanding of what is known about the state's environment, what information is needed, and what the potential problem areas might be and possible ways of addressing them and measuring success.

Valuable insight can be gained by viewing indicators with reference to the "pressure-state-effects-response" conceptual model, which is discussed in Chapter 1. The diagram on the following page extends the model to include driving forces that can produce pressures upon the environment. Some of the background indicators in this report reflect trends in these "driving forces." One such driving force is population growth. Already the most populated state in the country with its estimated 35 million residents, California continues to grow faster than the rest of the nation, adding over half a million people to its population every year for the past four years. Significant pressures are exerted on the state's environment and natural resources by the size and growth rate of the population. In addition, population growth influences other significant driving forces such as the economy, land use, the need to move people and goods, and energy use.

Certain environmental indicators in this report show trends that are consistent with the state's goals of improving, restoring or preserving the environment. For example, emissions and ambient levels of certain air pollutants generally show declining trends. Contaminants in drinking water are rarely found at levels exceeding regulatory standards. Increasingly more solid waste is being diverted from landfills, and less hazardous waste is produced per unit of economic activity. The positive trends in these areas are attributable in large part to current environmental programs.

Other indicators show a lack or improvement or a worsening of environmental conditions. The population of winter run Chinook salmon in the Central Valley has declined to extremely low levels. The clarity of Lake Tahoe, an indicator of overall lake function, continues to decline. The population of the desert tortoise, a federally designated endangered species, has declined significantly since 1980. In some air basins, levels of inhalable particulate matter have not been significantly reduced over the last ten years.

Finally, additional challenges stem from a lack of data with which to gauge the status of certain environmental issues. For example, status and trend data are lacking on such issues as indoor air quality, the impacts of pesticide



The Pressure–State–Effects–Response Model
"Driving forces" that produce pressures
Population growth
Economic expansion or shifts
Movement of people, goods
Energy use
Material use
Societal attitudes (consumerism, regulatory compliance, environmental responsibility)
Technological/Scientific advancements
Government and other institutions
Globalization
PRESSURES
Physical, biological, chemical stresses on the environment
Emissions
Discharges
Wastes
Pesticides
Land Use
STATE
Environmental conditions
Air
Water
Land
Natural resources
EFFECTS
Human health
Ecosystem health
RESPONSE
Regulatory actions
Societal actions

use on air and water quality, the impacts of environmental exposures on human health, and many aspects of the state's natural resources.

Key findings and future directions for each issue area are discussed below.

Air Quality

Extensive monitoring of air pollutants by the state originally arose out of the need to tackle some of the worst urban air pollution in the country. Over the past 20 years, technological advances and regulatory strategies have yielded significantly cleaner air. The indicators for air quality show the following:

- Criteria air pollutants, most of which arise from combustion of petroleum products, are the major pollutants found in urban smog. Levels of inhalable particulate matter (PM10) have been only modestly reduced in the major air basins and not significantly in a few others. Urban sources of PM10 currently represent one of the biggest challenges in reducing air pollution. While ozone still exceeds California standards in five major air basins, significant improvements have occurred in all air basins over the last 20 years. Carbon monoxide has ceased being a major air pollutant in all areas of the state, except in some Mexican border areas and in the South Coast Air Basin, where exceedances of the standard occasionally occur.

- Toxic air contaminants include over 180 chemicals, many of which are potential carcinogens. EPIC indicators to describe the levels and risks associated with these substances in California's air are under development. However, initial data show an overall 40 percent reduction in emissions and ambient concentrations of toxic air contaminants in urban air basins over the last 10 years.

- One of the most intuitive measures the public uses to assess air quality is visibility. A comprehensive, consistent indicator of the degree of clarity of the atmosphere is currently under development. Small particles in the air are a major component in causing visibility impairment.

- Pollutants found indoors may present a greater hazard than outdoor pollutants. Indoor pollution is not monitored on an ongoing basis to provide an indicator, although current research has focused on sources of, and levels of exposure to, indoor pollutants. Indoor air quality is a significant issue requiring data collection for indicator development.

Future EPIC updates will include indicators for very small inhalable particulate matter (PM2.5) produced primarily by combustion, an emissions inventory for toxic air pollutants, and community-based air quality indicators.

Water

California's water needs must be met by an adequate supply of water of the quality appropriate for many purposes (called "beneficial uses"), including drinking, swimming, fishing, supporting aquatic life and habitat, and agricultural and industrial uses. The indicators for water show the following:

- Since 1984, less than one percent of the 20,000 municipal drinking water sources in the state contain concentrations of contaminants that exceed drinking water standards.

- The number of leaking underground fuel tank sites has been declining since 1995, a trend resulting from the upgrading of nearly all active tanks. Of the 38,000 tanks examined in 2000, 17,000 were leaking; approximately 15 percent of these are potential threats to drinking water supplies.

- Commercial shellfish growing waters, which have been monitored for over a decade, continually meet the regulatory standard for fecal coliform bacteria during the open harvesting periods.

- An indicator of short-term impairment, the number of sewage and petroleum spills into water, increased by 33 percent, from 1,445 in 1997 to 1,918 in 2000. The number of sewage spills alone increased by 76 percent.

- Data to present trends in surface water quality – in terms of the extent by which surface waters support beneficial uses (such as aquatic life protection and swimming) — are not available. A snapshot of the 2000 assessment is presented. Trends will result with implementation of new monitoring programs.

- Coastal beach closures due to bacterial contamination increased 15 percent from 1999 to 2000. With the recent standardization of beach posting protocols, more consistent and meaningful trends will be available in the future.

- Trends presented for the safety of consuming fish caught from coastal areas are based on assessments done on 35 percent of the total number of acres of bays and estuaries, and on 12 percent of the total ocean coastline miles. The assessments determine whether the levels of chemical contaminants found in sport fish caught from a water body are such that the general public can safely eat at least one meal a week. Between 1995 and 2000, the safety of consuming fish from coastal waters remained stable; the safety of consuming fish from bays and estuaries appears to have declined.

- Because water supply is a major concern for California, forecasting of water needs has been going on for many decades. Largely due to the state's increasing population, the urban water use has increased from 1994 to 1998. At the same time, agricultural water use has leveled off.

- Per capita urban water use production has increased since 1940.

- Recycling or reuse of municipal wastewater increased by 50 percent in the past 13 years.

Establishing a comprehensive set of water indicators presents a formidable challenge. Until recently, comprehensive and consistently collected data needed for indicator development were lacking for many beneficial uses of water. In the future, it is expected that a more complete picture of California's water quality can be presented. Data to be collected under the State Water Resources Control Board's (SWRCB) Surface Water Ambient Monitoring Program will greatly enhance the state's ability to track trends in surface water quality. Similarly, the groundwater indicators will be enhanced by information generated by the SWRCB's Groundwater Ambient Monitoring Assessment Program. To track the safety of consuming fish from inland waters, efforts similar to those taken under the Office of Environmental Health Hazard Assessment's Coastal Fish Contamination Program are needed to collect the necessary data.

Land, Waste And Materials Management

Waste is a by-product of human activity and, if not managed properly, can exact considerable costs in terms of lost resources, environmental contamination, and adverse effects on human health. California's waste management programs seek to reduce the potential for such adverse impacts by promoting reuse or recycling to divert wastes from landfills or the prevention of waste generation in the first place, and through regulations designed to ensure the safety of waste storage, treatment and disposal. Where past practices have contaminated land, water and air, the state performs or oversees the cleanup of sites to prevent further contamination and harmful human exposures to hazardous constituents or decomposition products of the waste. Indicators relating to solid and hazardous wastes show that:

- Statewide diversion of solid waste has increased by 500 percent over the past 11 years, from 5 million tons diverted in 1989 to 28 million tons in 2000. Although waste generation increased during the same period, disposal at landfills has decreased by 13 percent, declining from 44 million tons in 1989 to 38 million tons in 2000.

- The disposal of waste tires has decreased over the past 10 years, while diversion has more than doubled, from an estimated 9.2 million tires in 1990, to 23 million in 2000. The development of viable markets for used tires is a key to continuing this trend.

- The amount of hazardous waste generated and shipped for treatment or disposal over the past seven years has increased by 16 percent, from 2.3 million tons in 1993 to 2.7 million tons in 2000. However, when economic activity is taken into consideration, waste generation has declined by 30 percent.

- Both recycling and disposal of hazardous waste in landfills have increased since 1993. In 2000, 40 percent of hazardous wastes ended up in landfills while about 33 percent was sent to recyclers.

- No clear trends were noted for hazardous material spills or soil cleanup at hazardous waste sites.

Future efforts will attempt to address site contamination and the impact of remediation efforts on the environment, and the impacts of households on the overall solid and hazardous waste streams.

Pesticides

Pesticides are unique among toxic chemicals in that they are deliberately released into the environment to achieve a specific purpose. While pesticides have brought significant benefits, they have the potential to adversely impact human and ecological health because of their inherent toxicity. Hence it is important to track the human and ecological effects of pesticides, as well as the presence of pesticides in air, water or produce. The pesticide indicators in this report show that:

- Less than two percent of the fruits and vegetables sampled since 1989 contained illegal residues of pesticides. More than 7,000 samples are tested annually.

- Reported Illnesses related to occupational pesticide exposures declined by about 60 percent in the past decade (from 2,016 reports in 1988 to 804 in 1999), occurring less frequently in agricultural settings.

- Pesticide contamination of groundwater can only be partially characterized at this time. Limited information is available on the magnitude and scope of the impacts of pesticides in surface water.

- No ongoing monitoring for pesticides that have been identified as toxic air contaminants is being conducted at present.

Future efforts will focus on developing a meaningful indicator of pesticide use based on environmental and toxicological considerations, characterizing the presence of pesticides on air and water quality, enhancing the indicator for pesticide-related illnesses, and tracking the ecological impacts of pesticides.

Transboundary Issues

The movement of certain pollutants by natural processes, meteorological forces, and human activities can produce environmental threats which extend beyond California's geographical boundaries. Conversely, pollutants which originate in other states, countries or ecosystems, carried by atmospheric air currents, watersheds, trade, and travel can impact California. In this report, the transboundary issues include global climate change, stratospheric ozone depletion, pollution in the California/Baja California, Mexico border region, and invasive species. The transboundary indicators show that:

- Compared to the rest of the United States, California emits less of the greenhouse gas carbon dioxide, when calculated per person and per unit of the economy. However, compared with other developed nations, California emits more.

- California air temperatures have gone up approximately 1 degree Fahrenheit (1°F) in rural areas over the past century, compared to an increase of about 3°F in cities with the "urban heat island effect," which can skew temperature readings. Global air temperatures are estimated to have increased by 0.5°F to 1.0°F since the late 19th century.

- Global warming may escalate sea level rise. California's mean sea level as shown by tidal measurements in the past century has risen, but local land subsidence, and conversely, geologic uplifting of land mass can affect tidal calculations.

- The protective stratospheric ozone layer has gradually decreased over the mid-latitudes of the Northern Hemisphere (including California and the continental U.S.) from 1979 to the early 1990s. However, the downward trend has not continued in recent years as levels of ozone-depleting substances, including bromine and chlorine, stabilize in the stratosphere. Due to additional atmospheric processes that occur in the Polar Regions, ozone depletion in these regions is generally greater than over California.

- California and Mexican air monitoring stations in the San Diego/Tijuana and Imperial Valley/Mexicali border areas reported peak ozone, carbon monoxide and inhalable particulate matter (PM10) concentrations that continue to exceed California air quality standards.

In the future, some of the efforts to address climate change issues will investigate emissions of other greenhouse gases such as methane and nitrogen oxide emissions; correlate the ocean's offshore sea surface temperature influence on inland air temperatures; and study trends in soil moisture, precipitation intensity, wind velocity, sea wave height and intensity, plant blooming cycles, and animal and insect migrations. With respect to trans-border pollution issues, future efforts will focus on water quality in the border region, and the movement of hazardous waste to and from Mexico and other areas outside California.

Human Health

The health of Californians is generally very good and improving as a result of many factors, including advances in health care, healthier lifestyles, and reduced exposures to environmental pollutants. Infant mortality rates continue to decrease, from almost 8 deaths per 1,000 live births in 1990 to slightly more than 5 deaths per 1,000 live births in 1999. The life expectancy of Californians continues to increase, and compares favorably to national averages. (In 1997, life expectancy at birth was 75.5 years for males and 80.7 years for females in California, compared to 73.6 for males, and 79.4 for females nationally.) Despite these improvements, some human health conditions appear to be getting worse. For example, asthma rates have been increasing over the years, for reasons not yet well understood.

Most environmental protection programs are aimed at protecting human health against harmful exposures to environmental contaminants. Many of the indicators in this report relate to human health. Indicators presented in the human health section are those that reflect the impacts of exposures to environmental contaminants directly on people: the retention of toxic chemicals in human body tissues, and human conditions and diseases related to environmental exposures. Although it is known that certain environmental pollutants influence disease, other factors including genetics and lifestyle also play a role. The degree to which these various factors contribute to reported diseases or conditions from environmental pollutant exposures is largely undetermined, making it difficult to identify a cause and effect relationship that would support the development of indicators at the present time.

Developing human health indicators will require monitoring data on the occurrence and levels of bioaccumulative chemicals in the human body, such as certain toxic organic compounds, and inorganic compounds such as lead and mercury. Currently, lead is the only bioaccumulated substance for which levels in the human body are tracked and reported to the state, and only in cases when measured levels exceed a certain standard. Only two facilities report blood lead levels for all children tested; these data are not necessarily representative of children's blood lead levels in the California population.

In the future it is hoped that better surveillance of diseases and conditions, and research to relate disease occurrences to exposure to environmental chemicals, will assist indicator development.

Ecosystem Health

An ecosystem is an interdependent grouping of living and non-living components in the environment. The report addresses the health of four natural ecosystems (forests, grasslands and rangeland; the desert; freshwater aquatic; and coastal aquatic) and two ecosystems managed for the benefit of people, urban and agricultural.

The key issues of concern in the natural ecosystems are: (1) preservation of habitat quantity and quality; (2) biodiversity; and, (3) maintenance of ecological function. Changes in the structural components of an ecosystem (habitat, species diversity) can ultimately alter ecological function and the integrity of the ecosystem.

For agricultural and urban ecosystems, those managed primarily for human use, important issues are similar to those for natural systems: sufficient quality and quanity of land, positive and negative environmental impacts, and sustainability.

Quality and Quantity of Habitat. Degradation of habitat, including fragmentation into small, disconnected pieces, is a key factor in the reduction of ecosystem integrity. Overall, the indicators suggest that natural resources and habitat for plants and wildlife are under significant pressure in the state. An average of 45,000 acres per year are being converted from agriculture and rangeland to urban and other uses. In the past 15 years, about 1.2 million acres of the 1982 base acreage of forest and rangeland have been converted to other uses. Siltation and eutrophication associated with nutrient run-off have reduced the clarity of Lake Tahoe. Significant alterations to California's rivers have made them unfit for many species of fish, in particular salmon.

Biodiversity. Overall, there is inadequate information on the status of threatened and endangered species in the state. The population status of about 20 percent of threatened and endangered plants and 35 percent of animals remains unknown. The populations of fewer than 5 percent of threatened and endangered plant species and about 15 percent of animal species are increasing. Information on specific species shows the following:

- The population of winter-run Chinook salmon in the Central Valley, one of the threatened and endangered species for which reasonably good information exists, continues to decline to perilously low levels. At present, these salmon spawn in only a handful of streams and have a population estimated to be less than 1,500 fish.
- The population of the least tern, a coastal shorebird, appears to be stable at present.
- The population of the threatened desert tortoise, an indicator for the desert ecosystem, has declined to very low levels.
- In two important forested areas that cover the Sierra and Cascade mountain ranges along the eastern portion of the state, the extent of the canopy of both hardwood and conifer trees has increased.

Ecosystem Function. Identifying the appropriate measures of ecosystem function is challenging. The only measure included in this report is the clarity of Lake Tahoe. Lake clarity, a measure of eutrophication (nutrient loading) as well as sedimentation, reflects many processes that occur within a lake. As an indicator, lake clarity captures multiple ecological processes of a lake, reflecting significance beyond the simple measurement of clarity. The decrease in clarity of Lake Tahoe over the past 30 years suggests that ecological functions in the lake are declining.

In some areas, little if any information is presently available for indicator development. These are identified as Type III indicators or data gaps:

- Data on the extent and distribution of exotic or non-native plants in the desert are needed to gain an understanding of the health of the desert, the most overlooked ecosystem in the state.
- While frog deformities and deaths have been documented elsewhere in the nation, scant information is available on the status of amphibian populations of the Sierra Nevada.
- Significant national efforts are underway to understand the effects of endocrine-disrupting chemicals on wildlife. In particular, treated wastewater has been shown to cause harmful effects on fish, including salmon. Information on the presence of such chemicals in California's waters needs to be collected.
- Indicators that address invasive species (also discussed as a transboundary issue) for specific ecosystems are needed.
- Persistent organic pollutants, known to cause reproductive harm and cancer, have been found in marine mammals throughout the world. Existing pilot studies suggest that these chemicals bioaccumulate in harbor seals in San Francisco Bay. Regular monitoring of seals in the state's bays and coastal areas would permit detection of problematic levels of organic contaminants.

Future efforts will address the need for indicators for agricultural and urban ecosystems and development of an indicator on the status of wetlands.

The greatest obstacle encountered in the development of ecosystem health indicators was the lack of reliable scientific information. Long-term, regionally-based, statistically-robust ecosystem monitoring is needed to provide data for indicator development. A focus on sensitive ecological areas and coordination of efforts between the Resources Agency (especially the Legacy Project), Cal/EPA, federal agencies, and non-government organizations would enhance such an effort.

Future Directions For EPIC

The EPIC Project will aim to maintain an environmental indicator system that conveys meaningful information about key environmental issues in the state and serves a critical role in the decision-making processes in environmental programs. This will be accomplished by ensuring that the indicator system covers all pertinent issues, expanding into additional issues (such as sustainability, environmental justice and pollution prevention), if deemed appropriate; that the interrelationships among the issues are better understood; that regional indicators are developed where needed to convey more meaningful information; and that factors that influence trends are evaluated to better understand how they may be addressed by environmental programs.

Development of the indicator framework began with the identification of environmental issues that need to be better understood through indicators. The initial organization of these issues parallels the areas of responsibilities of state environmental programs. This organization facilitated the identification of possible indicators and available data. However, it also lent a program-based perspective, which may have narrowed the definition of issues and identification of possible indicators. It is necessary to better understand how pollutants, wastes, the environment, human health, ecological health, and natural resources can influence one another. Alternative ways of organizing issues will be explored to promote a more comprehensive view of the issues and their possible relationships.

To be most useful, environmental indicator systems must take advantage of new scientific knowledge, better analytical capabilities, regulatory changes, new technologies, and adapt to shifting priorities. For example, geographic information systems (GIS) represent a technological tool that will be used to enhance EPIC's ability to evaluate, manage and present indicator information. EPIC will also coordinate its activities with efforts under the Office of Environmental Health Hazard Assessment's Emerging Environmental Challenges Program to identify and characterize issues that may confront the state in the future. Updates of the EPIC report will be published every two years.

Finally, EPIC will continue to rely on, and endeavor to strengthen, collaborations with a variety of partners in state government as well as local governments, the regulated community, community groups and other parties with an interest in California's environment. Communicating information to a broad audience will be emphasized through the EPIC web site (www.oehha.ca.gov), regional meetings and other means.

The EPIC Project is an ambitious undertaking to better understand what is happening in the environment in order to find effective ways of preserving and improving it. This undertaking is still in its formative stage. The process for identifying and developing indicators has been established, and an initial set of indicators presented, but much work remains to be done. In the end, the development of meaningful, well-founded environmental indicators will yield substantial rewards for California by optimizing the efforts of its environmental and natural resource programs.

California Air Resources Board

California Air Resources Board

Table 1. The initial set of environmental indicators

The issues represented by the indicators are shown as italicized text. Each indicator is classified based on the availability of data, as follows:

Type I: adequate data are available for presenting a status or trend.

Type II: further data collection/analysis/management is needed before a status or trend can be presented.

Type III: conceptual indicators for which systematic data collection is not in place.

Air Quality Indicators

Criteria Air Pollutants

Ozone

Days with unhealthy levels of ozone pollution (Type I)

Peak 1-hour ozone concentration (Type I)

Exposure to unhealthy ozone levels in the South Coast air basin (Type I)

Emissions of ozone precursors —Volatile organic compounds + Oxides of nitrogen (Type I)

Particulate matter (PM10)

Days with unhealthy levels of inhalable PM10 (Type I)

Peak 24-hour PM10 concentration (Type I)

Annual PM10 concentration (Type I)

Total primary and precursor PM10 emissions (Type II)

Carbon monoxide

Days with unhealthy levels of carbon monoxide (Type I)

Peak 8-hour carbon monoxide concentration (Type I)

Carbon monoxide emissions (Type I)

Toxic air contaminants (TACs)

Total emissions of TACs (Type II)

Community-based cancer risk from exposure to TACs (Type II)

Cumulative exposure to TACs that may pose chronic or acute health risks (Type II)

Visibility

Visibility on an average summer and winter day and in California national parks and wilderness areas (Type II)

Indoor air quality

Household exposure of children to environmental tobacco smoke (Type I)

Indoor exposure to formaldehyde (Type III)

Water Indicators

Water quality

Multiple beneficial uses

Aquatic life and swimming uses assessed in 2000 (Type I)

Spill/Release episodes – Waters (Type I)

Leaking underground fuel tank (LUFT) sites (Type I)

Groundwater contaminant plumes – Extent (Type II)

Contaminant release sites (Type II)

Drinking water

Drinking water supplies exceeding maximum contaminant levels (MCLs) (Index)

Recreation

Coastal beach availability – Extent of coastal beaches posted or closed (Type I)

Fish and shellfish

Bacterial concentrations in commercial shellfish growing waters (Type I)

Fish consumption advisories – Coastal waters (Type I)

Fish consumption advisories – Inland waters (Type III)

Water supply and use

Statewide water use and per capita consumption (Type I)

Water use efficiency – Recycling municipal wastewater (Type I)

Groundwater supply reliability (Type III)

Land, Waste and Materials Management Indicators

Waste generation

Waste generation, in general

Statewide solid waste generation, disposal and diversion, per capita (Type l)

Number of tires diverted from landfills (Type I)

Hazardous waste shipments (Type I)

Federal and California-only hazardous waste generation (Type II)

Accidents/disasters/spills/releases

Hazardous material incidents (Type I)

Waste importation/exportation

Hazardous waste imported/exported (Type II)

Disposal to land

Statewide solid waste disposal per capita (Type I)

Hazardous waste disposal (Type I)

Site contamination

Cleanup of illegal solid waste disposal sites (Type II)

Tire cleanup (Type II)

Soil cleanup (Type I)

Contaminated sites (Type I)

Daryn Dodge

U.S. Department of Agriculture

Cross-media contamination

Number of environmental releases from active landfills (Type III)

Groundwater contaminant plumes – Extent (see Water section)

Contaminant release sites (see Water section)

Pesticide Indicators

Air

Number of detections of pesticides identified as toxic air contaminants and the percent that exceeds numerical health standards each year (Type III)

Water

Area with pesticides detected in well water (Type I)

Simazine and breakdown products in a monitoring network of 70 wells in Fresno and Tulare Counties (Type I)

Pesticide detections in surface water and the percent that exceeds water quality standards (Type III)

Pesticides in food

Percent of produce with illegal pesticide residues (Type I)

Pesticide use

Pesticide use volumes and acres treated, by toxicological and environmental impact categories (Type II)

Integrated pest management

Number of growers adopting reduced-risk pest management systems and the percent reduction in use of high risk-pesticides (based on Alliance grant targets) (Type II)

Human health

Number of reported occupational illnesses and injuries associated with pesticide exposure (Type I)

Ecological health

Number of reported fish and bird kills due to pesticide exposure each year (Type II)

Transboundary Indicators

Global pollution

Climate change

Carbon dioxide emissions (Type I)

Air temperature (Type l)

Annual Sierra Nevada snowmelt runoff (Type I)

Sea level rise in California (Type I)

Stratospheric ozone

Stratospheric ozone depletion (Type I)

Trans-border pollution

California-Baja California, Mexico border issues

Air pollutants at the California/Baja California, Mexico border (Type I)

U.S. Department of Agriculture

Domestic border issues

Amount of hazardous waste imported/exported (See Land, Waste and Materials Management Section) (Type II)

International border issues

Ballast water program (Type III)

Indicators of Environmental Exposure Impacts Upon Human Health

Human body concentrations of toxic chemicals

Surveillance of persistent organic pollutants in body tissues and fluids

Concentrations of persistent organic pollutants in human milk (Type III)

Lead in children and adults

Elevated blood lead levels in children (Type II)

Mercury in children and adults

Mercury levels in blood and other tissues (Type III)

Ecosystem Health Indicators

Land cover and management & threatened and endangered species

Land cover

Land cover of major terrestrial ecosystems in California (Type I)

Land management

Land management in California (Type I)

Threatened and endangered species

California threatened and endangered species (Type I)

Health of aquatic and coastal ecosystems

Aquatic life protection and biodiversity

Status of Central Valley chinook salmon populations (Type I)

California least tern populations (Type I)

Persistent organic pollutants in harbor seals (Type III)

Habitat and water quality protection

Clarity of Lake Tahoe (Type I)

Stream bioassessment - invertebrate populations (Type II)

Endocrine-disrupting chemicals in aquatic ecosystems (Type III)

Desert ecosystem health

Alteration in biological communities

Status of the desert tortoise population (Type I)

Habitat degradation

Impacts of off-highway vehicles on the desert (Type II)

Distribution of exotic plants (Type III)

Daryn Dodge

Health of forests, shrub land, and grassland (terrestrial) ecosystems

Habitat quality and quantity

Change in habitat quantity in rangelands and forests (Type I)

Change in forest canopy (Type I)

Pest and disease related mortality in forests (Type I)

Wildfires in forests and grasslands (Type I)

Sustainability of California's forests (Type I)

Loss of biodiversity

Status of northern spotted owl (Type II)

Status of amphibian populations (Type III)

Ozone injury to pine needles (Type III)

Agroecosystem health

Availability of natural resources

Conversion of farmland into urban and other uses (Type I)

Soil salinity (Type II)

Positive and negative environmental impacts

Urban ecosystems

Urban tree canopy (Type III)

Background Indicators*

Population Demographics

Total California population

Annual population growth

Economy

Gross State Product (GSP)

Energy Consumption

Total energy consumption vs. GSP

Energy consumption in California by sector (transportation, industrial, residential, and commercial)

Residential energy consumption per household

Transportation

Motor gasoline consumption, vehicle miles traveled, and efficiency

Human Health

Life expectancy at birth for the United States and California; including a status of leading causes of death in California

Infant death rate

Self-reported asthma prevalence among adults in California and U.S.

Estimated U.S. annual average rate of self-reported asthma

Water supply

California's water supplies with existing facilities and programs

Land use

Progression of development of California's land

* Background indicators do not represent particular environmental issues in themselves, but provide information with which to interpret the meaning of various environmental indicators presented in this document.

CHAPTER 1

Introduction

The Directive

The California Environmental Protection Agency (Cal/EPA) released its first *Strategic Vision* document in July 2000 (Cal/EPA, 2000). In that document, Secretary Winston H. Hickox called for a new agency orientation based on the use of novel strategies to address the complex environmental challenges of the twenty-first century. Secretary Hickox also committed Cal/EPA to focus on measurable environmental results in judging the effectiveness of the state's environmental protection programs. To support this commitment, Cal/EPA made the adoption of environmental indicators a priority in the Agency's planning and decision-making processes.

Recognizing the need to address environmental protection issues in tandem with resource management issues, Secretary Hickox and Resources Secretary Mary Nichols agreed to collaborate in the development of environmental indicators for areas where the missions of the two agencies overlap. (Indicators that address areas that are primarily the responsibility of the Resources Agency will be developed and implemented under that agency's strategic planning functions.)

Environmental indicators present scientifically-based information on the status of, and trends in, environmentally-related parameters. They convey complex information in a concise, easily understood format, and have a significance extending beyond that directly associated with the measures from which they are derived. Environmental indicators will support the development and implementation of a "results-based management system" for Cal/EPA. Under this management system, environmental indicators will be considered in strategic planning, policy formulation, resource allocation, and priority setting. The environmental indicators will also be used to communicate information about California's environment to the public.

Specifically, environmental indicators will help track progress toward meeting the following goals specified in Cal/EPA's *Strategic Vision*:

- Air that is healthy to breathe, and sustains and improves our ecosystems, and natural and cultural resources.
- Rivers, lakes, estuarine, and marine waters that are fishable, swimmable, and support healthy ecosystems and other beneficial uses.
- Groundwater that is safe for drinking and other beneficial uses.
- Communities that are free from unacceptable human health and ecological risks due to exposure from hazardous substances and other potential harmful agents.
- Ensure the efficient use of natural resources.
- Eliminate the disproportionate impacts of pollution on communities.

The Office of Environmental Health Hazard Assessment (OEHHA) was directed to lead a collaborative effort to develop a process for identifying and selecting environmental indicators, to generate an initial set of indicators, and to maintain the environmental indicator system. The Environmental Protection Indicators for California (EPIC) Project was created to carry out this directive. Over the past year, OEHHA has worked closely with various collaborators, including technical staff from the boards and departments of Cal/EPA, the Resources Agency, the Department of Health Services, and Region 9 of the U.S. Environmental Protection Agency (U.S. EPA). Input into the project is provided by an Interagency Advisory Group of policy-level representatives from various state agencies and U.S. EPA, and by an External Advisory Group consisting of representatives of non-profit environmental/public interest groups, local governments, the private sector, and academia.

This document describes the process that will guide the identification and selection of environmental indicators; this process may be revised, as needed. This document also presents the initial set of environmental indicators. This initial set will be evaluated, improved and expanded on an ongoing basis to ensure that it provides meaningful information for better understanding the state of California's environment, and for planning and decision-making.

Overview of Environmental Indicators

Increasing concern over environmental issues in recent decades has prompted efforts to develop environmental indicators. These indicators provided a means of simplifying environmental data for decision-makers and the public (Hammond, 1995). The early work of the Organisation for Economic Co-operation and Development (OECD), an international organization charged with promoting policies to achieve sustainable economic growth, was most notable in the field. In 1989, the OECD Council called for further work to integrate environmental and economic decision-making (OECD, 1993), a charge that was echoed in a request to OECD by the Group of Seven economic powers after its Economic Summit in the same year. The OECD also launched a program of environmental performance reviews to help improve the individual and collective performance of its member countries in environmental management.

Environmental indicators are used by international organizations (such as OECD and the United Nations), by many countries (most notably The Netherlands, Canada, New Zealand, and Australia), by the federal government (U.S. EPA), by other states (such as New Jersey and Florida), and by governmental and non-governmental organizations at the regional and local levels (such as the City of Santa Monica and the Silicon Valley Environmental Partnership). Uses of environmental indicators by these various entities range from the communication of information about the state of the environment to providing specific considerations for strategic planning, goal-setting, and policy-making. (See reference list at the end of this chapter for full citations for indicator reports and/or web sites for these various entities.)

Conceptual Model for Environmental Indicators

Most environmental indicator systems are built around the "pressure-state-response" (PSR) model developed by OECD, or a variation thereof, such as the "pressure-state-effects-response" (PSER) model developed by the U.S. EPA's Office of Policy, Planning and Evaluation (U.S. EPA, 1995).

The PSER model is based on a concept of causality (see Figure 1). Human activities (as well as natural phenomena) exert pressures on the environment. For example, the use of leaded gasoline in vehicles until the 1970s resulted in lead emissions in vehicle exhaust. These pressures can change the quality and quantity of natural resources, the ***state***. In the example given, the lead emissions resulted in increased concentrations of lead in air, which can result in elevated human blood lead levels. Changes in the state can then produce one or more adverse ***effects*** on human and ecological health, e.g., reduced IQ in children, in the case of lead. Society may then react to these changes by enacting new policies and regulations, the ***response***. The banning of lead as a gasoline additive is an example. In principle, new policies or regulations should reduce the pressures on the state and, consequently, the effects. Certain responses may also be directed at the ***state***, such as efforts to clean up sites contaminated with leaded gasoline, or at the ***effects***, such as screening to identify and treat children with elevated blood lead levels. In some cases, the ***state*** may affect the pressure.

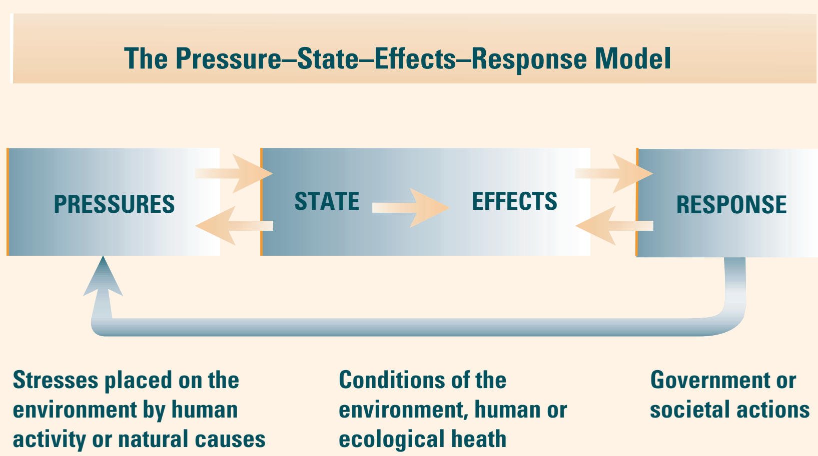


Figure 1

Adapted from: Organisation for Economic Cooperation and Development, 1993

References:

Australian and New Zealand Environment and Conservation Council. *Core Environmental Indicators for Reporting on the State of the Environment*. Posted at: www.environment.gov.au/soe/envindicators/coreindicators.html

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Hammond, A. et al. 1995. *Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development*. World Resources Institute, Washington, D.C.

The Netherlands. *Netherlands Measuring Environmental Progress 2000*. National Institute of Public Health and Environmental Protection. Bilthoven, The Netherlands. Posted at: www.netherlands-embassy.org/c_envind.html

New Jersey Department of Environmental Protection. *A Guide to Environmental Indicators in New Jersey: Managing for Environmental Results*. Posted at: www.state.nj.us/dep/dsr/guide.htm

A further refinement of the PSER model is used by the Chesapeake Bay Program, a partnership of federal, state and local governments, as its "hierarchy" of indicators (Figure 2) (U.S. EPA, 1999).

The indicators in this model can be characterized by their position in the hierarchy on a six-level scale, as follows:

Level 1: Actions by regulatory agencies
(example: issuance of a discharge permit)

Level 2: Responses by the regulated and nonregulated community
(example: compliance with allowable pollutant discharge limits)

Level 3: Changes in discharges/emission quantities
(example: discharge of a pollutant)

Level 4: Changes in ambient conditions
(example: water concentrations of a pollutant)

Level 5: Changes in uptake and/or assimilation
(example: uptake of pollutant by aquatic organisms)

Level 6: Changes in health, ecology or other effects
(example: changes in the population of aquatic organisms)

Administrative		Environmental			
Level 1	Level 2	Level 3	Level 4	Level 5	Level 5
Actions by EPA/State Regulatory Agencies	Responses of the Regulated & Nonregulated Communities	Changes in Discharge or Emission Quantities	Changes in Ambient Conditions	Changes in Uptake and/or Assimilation	Changes in Health, Ecology or Other Effects
Response		Pressure	State		Effects

Figure 2. The Chesapeake Bay Hierarchy of Indicators

Although the indicators toward the higher end of the continuum (Levels 4 through 6) portray a clearer, more direct image of the environmental conditions, indicators at the lower levels (Levels 1 through 3) are needed to establish a link between the actions taken and effects observed. It is important to maintain indicators along the continuum in order to demonstrate the linkage between human activities and responses in the natural system.

The focus of the EPIC Project is on the environmental indicators, Levels 3 through 6. Administrative indicators, Levels 1 and 2, are addressed in the strategic planning process.

References (cont.)

New Zealand Ministry for the Environment. *The State of New Zealand's Environment 1997.* Posted at: www.mfe.govt.nz/about/publications/ser/ser.htm

Organisation for Economic Co-operation and Development. 1993. *OECD Core Set of Indicators for Environmental Performance Reviews*. Environment Monographs No. 83. OCDE/GD(03)180. Paris.

Silicon Valley Environmental Partnership. *1999 Environmental Index*. Posted at: www.svep.org

United Nations Department of Economic and Social Affairs, Division for Sustainable Development. *Indicators of Sustainable Development: Framework and Methodologies*. Background Paper No. 3. Ninth Session, Commission on Sustainable Development, April 16-27, 2001, New York.

United Nations Environment Programme, Division of Environmental Information, Assessment and Early Warning. 1999. *Global Environment Outlook 2000*. United Nations Environment Programme, Nairobi, Kenya. Posted at: www.grida.no/geo2000/

U.S. Environmental Protection Agency, Chesapeake Bay Program. July 1999. *Environmental Outcome-Based Management: Using Environmental Goals and Measures in the Chesapeake Bay Program*. EPA903-R-99-014 CP/RRS 223/99. Posted at: www.chesapeakebay.net/pubs/indpub/indpub.htm

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CHAPTER 2

The Environmental Protection Indicators for California (EPIC) Process

Scope of the EPIC Project

The EPIC Project develops and maintains an environmental indicator system that:

- Reflects an issue that affects California, or a global or transboundary issue of interest to California.
- Relates to the missions of Cal/EPA and its boards, departments and offices. To the extent that these missions overlap with those of the Resources Agency, the Department of Health Services and other state agencies, those areas are addressed by the project. (Indicators that address areas that are primarily the responsibility of the Resources Agency will be developed and implemented under that agency's strategic planning functions.)
- Measures pressures exerted on the environment by human activities, ambient environmental conditions, or effects on human or ecological health. Measures of program performance, activity, efficiency or outputs are not within the scope of the project*.

These qualifying considerations guide the determination of important environmental issues and sub-issues from which indicators are developed.

The Indicator Identification and Selection Process

The process of identifying and selecting indicators under the EPIC Project is illustrated in the flowchart in Figure 3.

Identification of environmental issues.

The identification of significant environmental ***issues*** for California provides a focus for indicator development. Whenever possible, components of the issues, or sub-issues, are identified. Related issues and sub-issues are organized into an ***issue structure***. The issue structure provides a starting point for the identification of possible environmental indicators. The issue structure is intended to be flexible to allow the addition, removal or modification of issues and sub-issues in the future.

During the first year of the EPIC Project, issues were identified based on input from internal staff, as well as from participants at a two-day conference (*Environmental Protection Indicators for California: Building an Environmental Indicator System for Cal/EPA*, held January 18 and 19, 2001, in Sacramento), and the Interagency and External Advisory Groups. Similar issues were grouped into issue categories (air quality, water, land/waste/materials management, pesticides, human health, ecosystem health, and transboundary issues). Although various ways of organizing issues were explored, the issue categories chosen paralleled areas of authority within Cal/EPA. This facilitated the identification of possible indicators and data sources.

*Appendix B provides information on the range of indicators that can be used to assess an organization's performance.

Definition of Terms Used in EPIC

Parameter: A property (e.g., pollutant concentration, pollutant discharge quantity, chemical body burden) that is measured or observed.

Measure: indicator: Raw or analyzed data obtained from monitoring, surveys and other valid data collection methods. Measures form the basis for environmental indicators.

Environmental indicator: A value that presents scientifically based information on the status of, and trends in, environmentally-related parameters. An indicator conveys complex information in a concise, easily understood format, and has a significance extending beyond that directly associated with the measure(s) from which it is derived.

Integrative An indicator that captures multiple aspects of a given issue or system such that its significance extends beyond the measure(s) from which it is derived to a greater degree than other available indicators.

Index: A type of environmental indicator derived from a set of aggregated or weighted indicators or measures.

Indicator suite: A group of indicators that collectively presents information on major environmental issues, such as climate change, toxic contamination, biological diversity, hazardous waste, pesticides, ecosystem health, or use of natural resources (energy, fisheries, forests, public lands, soil and water).

Issue: A topic of environmental concern to California, including its components or dimensions, or sub-issues. Environmental issues can exist on a local to statewide scale, and provide the foundation for identifying environmental indicators.

Issue structure: The organization of issues and sub-issues that guide the development of environmental indicators.

Identification of relevant parameters.

Each issue is examined to determine whether relevant properties or ***parameters*** can be identified, which can then be used to derive candidate indicators. When an issue is not well understood, the appropriate parameters cannot be identified, indicating a need for further investigation.

Identification of candidate indicators.

Where one or more parameters can be identified for an issue, various ways of presenting these parameters, individually or in combination with other parameters, are identified.

Example of parameters and associated candidate indicators:

For ozone as a criteria air pollutant, parameters can include:

- emissions of ozone precursors (i.e., nitrogen oxides and volatile organic compounds);
- ambient ozone concentrations;
- number of exceedances of certain regulatory standards; and,
- vehicle-miles traveled.

Candidate indicators can include:

- total statewide ozone precursor emissions per year;
- statewide ozone precursor emissions per year per vehicle-mile traveled;
- maximum statewide ozone concentration per year; and,
- total number of days of exceedances of California standard.

Evaluation of candidate indicators based on primary criteria.

To ensure that EPIC indicators are of consistently high quality, candidate indicators are evaluated to verify that they meet all primary criteria. Data for each candidate indicator are assessed to ensure that they are collected using methods that are scientifically acceptable, and that they support sound conclusions about the state of the system or issue being studied. In addition, the indicator must closely represent the issue, be sensitive to changes in the issue being measured, and provide a meaningful basis for decision-making.

Ideally, an indicator should, at a minimum, meet all these criteria. However, there are special circumstances when the only available data set does not meet all primary criteria, but could nevertheless be used to develop a reasonably valid indicator. These guidelines allow for the selection of such indicators with the expectation that better quality data will be generated in the future. In these cases, the limitations of the data set(s) used for indicator development should be clearly documented in the narrative for the indicator.

When a candidate indicator does not meet the primary criteria and there is no prospect for the development of new data sets that would meet the criteria, the indicator is dropped from further consideration.

Guidelines for Indicator Selection: Primary Criteria

The indicator should meet all of the following criteria:

Data quality: Data are/will be collected to yield measures that are scientifically acceptable and support sound conclusions about the state of the system being studied.

Representativeness: The indicator is designed to reflect the environmental issue it is selected to characterize.

Sensitivity: The indicator should be able to distinguish meaningful differences in environmental conditions with an acceptable degree of resolution.

Decision support: The indicator should provide information appropriate for making policy decisions.

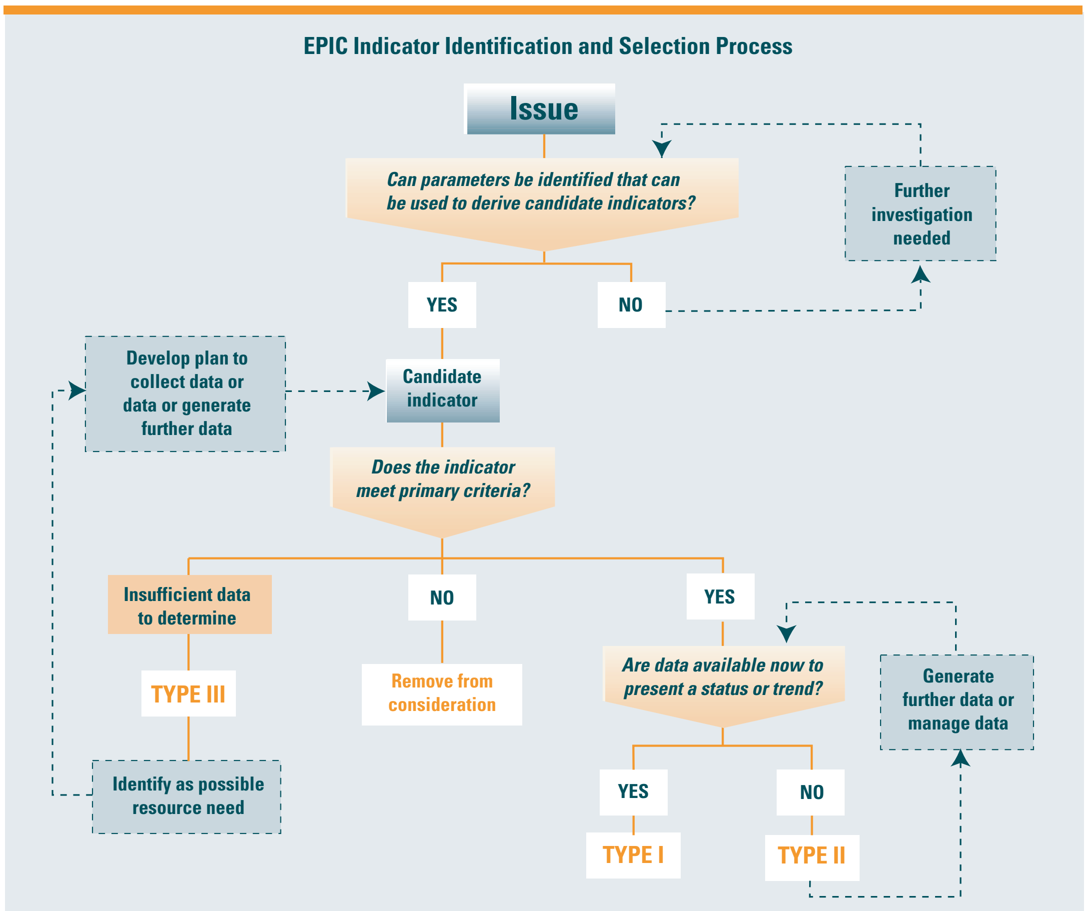


Figure 3

Characterization of data availability.

Candidate indicators meeting primary criteria are further evaluated as to whether data are available to present a status or trend for the issue in question. Where the data are available and are supported by ongoing, systematic monitoring and data collection efforts, the indicator is designated as a ***Type I indicator***.

When the data do not show a status or trend, either because a full cycle of data has not yet been collected, or the data require further analysis or management, the indicator is classified as a ***Type II indicator***.

There are instances when it cannot be determined whether a candidate indicator meets primary criteria because of insufficient data or because the data are from a one-time study. These indicators are classified as ***Type III indicators***. Type III indicators reveal a need for resources to develop a plan and/or implement a program for data collection.

Evaluation of Type I indicators based on secondary criteria.

Secondary criteria reflect other desirable, but nonessential, attributes of an environmental indicator. These criteria address whether an indicator can be used to anticipate changes, can be compared to indicators in other programs or systems, is cost-effective, and is based on, or can be compared to, a benchmark value. These characteristics are noted in the indicator sheets whenever appropriate.

Understandability is an essential characteristic of an environmental indicator. It is not a fixed attribute of an indicator, but rather a function of how the data for an indicator are presented. Where there can be several ways of presenting an environmental indicator, every effort is made to select the presentation that can be most easily understood by the broadest audience.

Classification of indicators based on data availability

Type I indicators: Adequate data are available and can be used to support the development of the indicator. These data are generated by ongoing, systematic monitoring or data collection efforts.

Type II indicators: Full or partial data generated by ongoing, systematic monitoring and/or collection are available, but either a complete cycle of data has not been collected, or further data analysis or management is needed in order to present a status or trend.

Type III indicators: No ongoing monitoring or data collection is in place to provide data for these indicators. At the present time, these indicators are conceptual or have not been developed beyond one-time studies that provide only a snapshot in time. Type III indicators are useful in revealing data gaps that may need to be filled in order to provide quantitative information on certain significant environmental issues.

Guidelines for Indicator Selection: Secondary Criteria

It is desirable, but not essential, that Type I indicators meet the following criteria:

Anticipatory: The indicator can provide an early warning of environmental change.

Data comparability: The indicator can be compared to indicators in other state, regional, national or international systems.

Cost-effective: Data collection efforts generate the type and amount of information needed to support the indicator, and can be carried out at a reasonable cost.

Benchmark value: The indicator is based on, or can be compared to, a benchmark value or point of reference, so that users can assess its significance.

Indicators integrate multiple aspects of a given issue or a system. Certain indicators can synthesize a considerable degree of information. These are termed ***integrative indicators***. The level of dissolved oxygen in a river or stream is an example of an integrative indicator. Oxygen is produced by plants and used by bacteria, invertebrates, and vertebrates. Its concentration in water reflects many interrelated processes within an aquatic ecosystem.

In certain cases, indicators can be combined, in a weighted or non-weighted fashion, into a single ***index*** to integrate a greater degree of information than the individual indicators.

Collectively, all the indicators that present information on an environmental issue comprise an ***indicator suite.***

CHAPTER 3

The Environmental Indicators

Introduction

This chapter presents the initial set of environmental indicators developed during the first year of the EPIC Project. Identification and selection of the indicators followed the process and criteria described in the previous chapter. Indicators are organized under separate sections for the following issue categories:

Air quality

Water

Land, Waste and Materials Management

Pesticides

Transboundary Issues

Environmental Exposure Impacts upon Human Health

Ecosystem Health

Although each section focuses on a specific issue category, the issues do not exist in isolation. Issues or indicators described in one section may impact, or be impacted by, other issue areas. For example, emissions of methyl mercury, formed as a result of bacterial action on mercury-containing wastes, have recently been measured in landfill gas. Methyl mercury emissions can result in deposition of the chemical into surface waters and their sediments, where the chemical can be assimilated by aquatic organisms, including fish, leading to ecosystem or human health consequences. The linkages among the various issue areas will be explored in subsequent editions of this report.

An additional set of "background indicators" is also discussed. These indicators reflect trends in certain demographic, economic, human health and other parameters that can provide a meaningful context with which to interpret some of the environmental indicators.

Chapter Organization

This chapter consists of eight sections: the seven environmental issue categories listed above, and the background indicators. Except for the background indicator section, each section includes, in the following sequence:

- An introduction to the issue category; this includes a summary list of the environmental indicators presented (with the issue or sub-issue they represent), and a description of the issues identified for the topic area;
- Individual indicator sheets for indicators classified as "Type I" indicators (i.e., indicators with adequate data supported by ongoing, systematic monitoring or data collection);
- Presentation of the "Type II" indicators (i.e., indicators for which data are generated by ongoing monitoring and/or collection, but either a full cycle of data has not been collected, or further data analysis or management is needed); and,
- Presentation of the "Type III" indicators (i.e., indicators that could be developed if ongoing, systematic data collection efforts are initiated).

Key to indicator information box

Level and Goal will be identified for Type I indicators only.

Type I

Level 4
Goal 2

Classification based on data availability: (abbreviated form)

Type I indicators: Adequate data are available, generated by ongoing, systematic monitoring.

Type II indicators: Full or partial data generated by ongoing monitoring, but further data collection/analysis/management necessary before a status or trend can be presented.

Type III indicators: Conceptual indicators for which there is no ongoing data collection (data gaps)

Level based on "pressure-state-effects-response" model Chesapeake Bay Hierarchy

Administrative		Environmental			
Level 1	Level 2	Level 3	Level 4	Level 5	Level 5
Actions by EPA/State Regulatory Agencies	Responses of the Regulated & Nonregulated Communities	Changes in Discharge or Emission Quantities	Changes in Ambient Conditions	Changes in Uptake and/or Assimilation	Changes in Health, Ecology or Other Effects
Response		Pressure	State		Effects

Cal/EPA Strategic Vision Goals* (abbreviated form)

1. Air that is safe for people and the environment
2. Lakes, rivers and streams that are swimmable and fishable
3. Groundwater that is safe for drinking
4. Minimal risk from hazardous substances
5. Reduce/eliminate differential exposure to contaminants in the population
6. Improve efficiency of natural resource use
7. Improve application of science to environmental protection
8. Improve efficiency of operations

For the full text of these goals visit:
www.calepa.ca.gov/Publications/Reparts/StratPlans/2002/

Background Indicators

Introduction

Background indicators provide information with which to interpret the meaning of various environmental indicators presented in this document. They do not represent particular environmental issues in themselves. The background indicators in this section present trends in demographic, economic and other factors that may directly or indirectly impact environmental conditions and resources in California.

Background Indicators

Population Demographics

Total California population

Annual population growth

Economy

Gross State Product (GSP)

Energy Consumption

Total energy consumption vs. GSP

Energy consumption in California by sector (transportation, industrial, residential, and commercial)

Residential energy consumption per household

Transportation

Motor gasoline consumption, vehicle miles traveled, and efficiency

Human Health

Life expectancy at birth for the United States and California; including a status of leading causes of death in California

Infant death rate

Self-reported asthma prevalence among adults in California and U.S.

Estimated U.S. annual average rate of self-reported asthma

Water supply

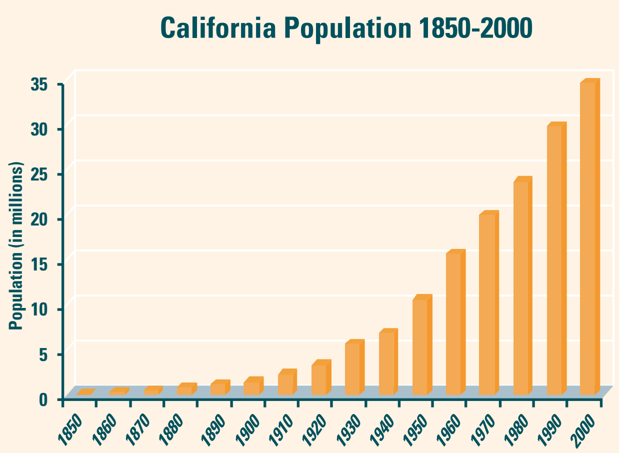
California's water supplies with existing facilities and programs

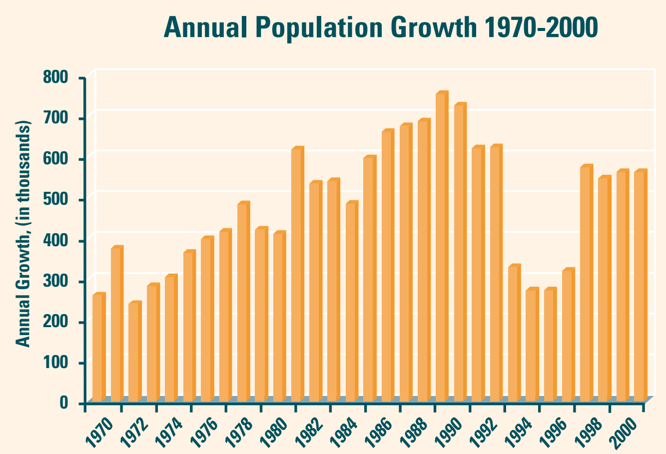
Land use

Progression of development of California's land

Population Demographics

As the state's population increases, so does the need for goods, energy, services, housing, and transportation. These demands, in turn, result in increased consumption of natural resources and increased production of wastes and other by-products. However, the impact of California's growth on the environment can be lessened to some extent through increased energy efficiency and conservation efforts, and better land use planning.





At present, California is home to an estimated 35 million people, making it the most populated state in the U.S. It took about 100 years to reach the 10 million mark, but since then California has been adding 10 million people every 20 years.

For the past four years, the state has been adding about 560,000 people annually – roughly equal to a city the size of Bakersfield or a state the size of Vermont. During this time, about half of the added population can be attributed to "natural increases" (births minus deaths) and half to net immigration (immigration into the state minus emigration out of the state).

By contrast, during the recession of the early 1990's, population growth was primarily due to natural increases; net immigration was low or negative.

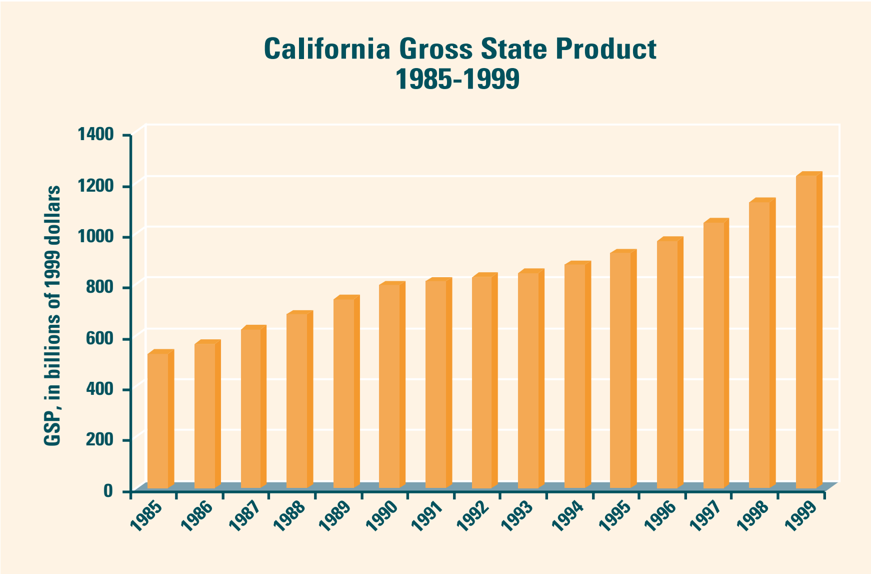
California's population is growing by roughly 1.6 percent per year – well above the nation's annual growth rate of about 1 percent per year.

Reference:

Legislative Analyst's Office. *Cal Facts: California's Economy and Budget in Perspective*, Sacramento, California, December 2000. Posted at: www.lao.ca.gov

Economy

The condition of the state's economy influences changes in the consumption of materials and energy, population growth rates and distributions, and consumer spending.



California's Gross State Product (GSP) has steadily increased over the last 15 years, but was slowed during the recession of the early 1990's. California lagged behind the nation in the early stages of the subsequent recovery, as declines in aerospace, banking, and certain other key industries in the state held growth down through the middle of the decade. Thereafter, however, the pace of the state's economy accelerated, with job growth exceeding the national rate in each of the past five years.

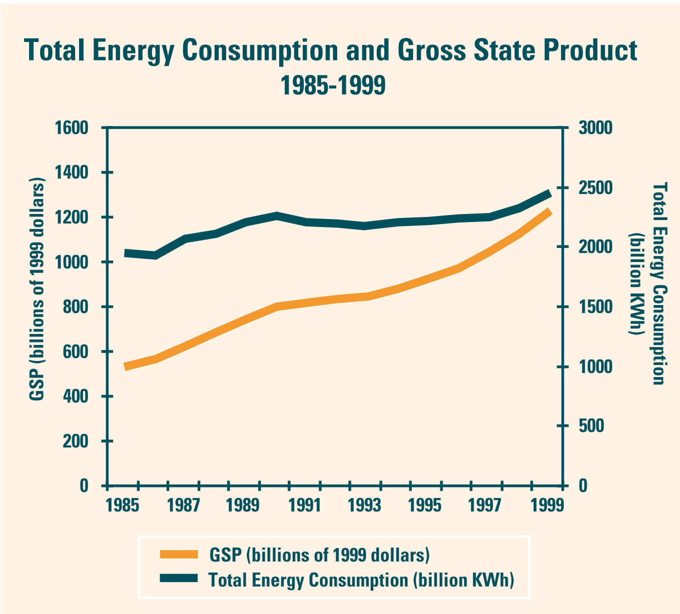
California's GSP exceeds $1.2 trillion, making it one of the world's largest economies. The California GSP trails only the U.S. (as a whole), Japan, Germany, and England. The California GSP accounts for 13 percent of the nation's output.

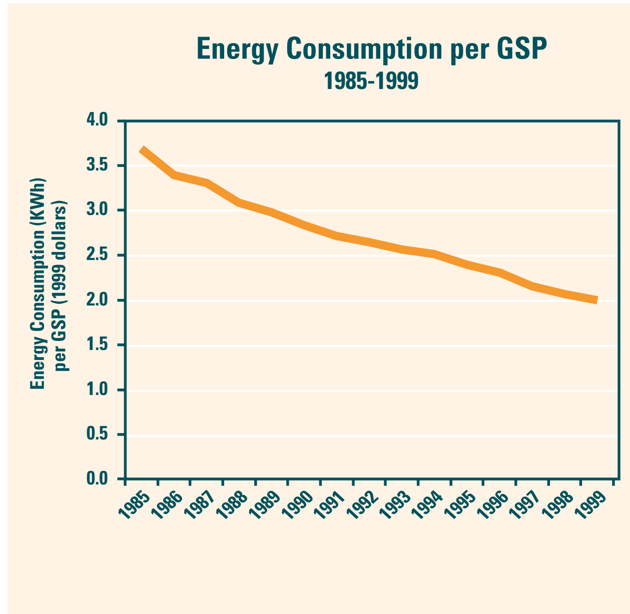
Reference:

U.S. Department of Commerce, Bureau of Economic Analysis, Gross State Product Data. Posted at: www.bea.doc.gov/bea/regional/gsp

Energy Consumption

The demand for energy across California influences everything from the price of products, to the quality of the air and water. Viewing energy trends in the context of economic trends provides a picture of the efficiency of the state's economy.





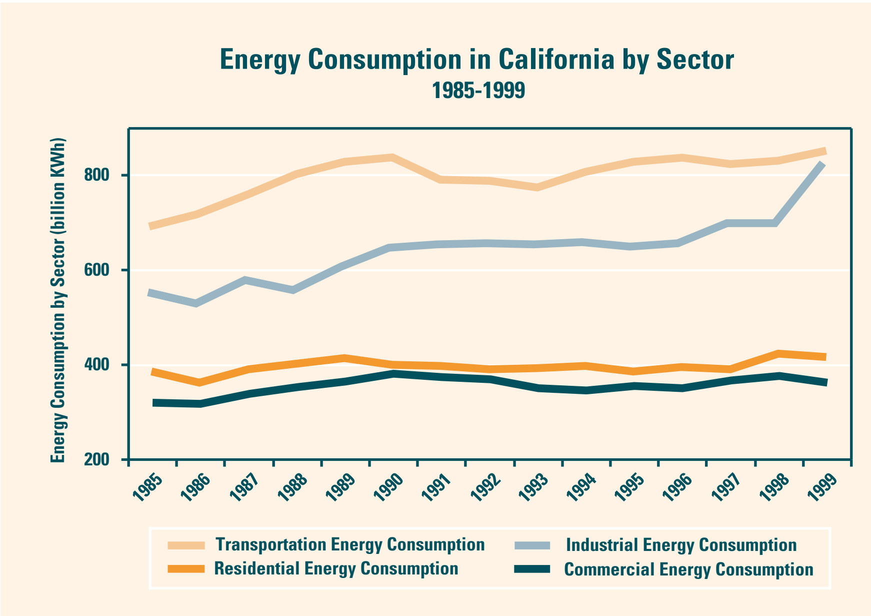
Over a 15-year period beginning in 1985, total energy consumption by the state has increased about 21 percent while the economy, expressed as Gross State Product (GSP), has grown at a greater rate of 57 percent. As a result, the amount of energy used to create one dollar of GSP has steadily followed a downward trend. In other words, California's economy has become more energy efficient.

A major reason for the declining energy trend relative to GSP is that California's economy has shifted over the past two decades from one in which manufacturing industries were dominant to one which is increasingly becoming services-oriented. Services-oriented industries generally consume less energy per GSP than manufacturing industries.

References:

U.S. Department of Commerce, Bureau of Economic Analysis Gross, State Product Data. Posted at: www.bea.doc.gov/bea/regional/gsp

Department of Energy, Energy Information Administration. *State Energy Data Report* 1999. Posted at: www.eia.doe.gov



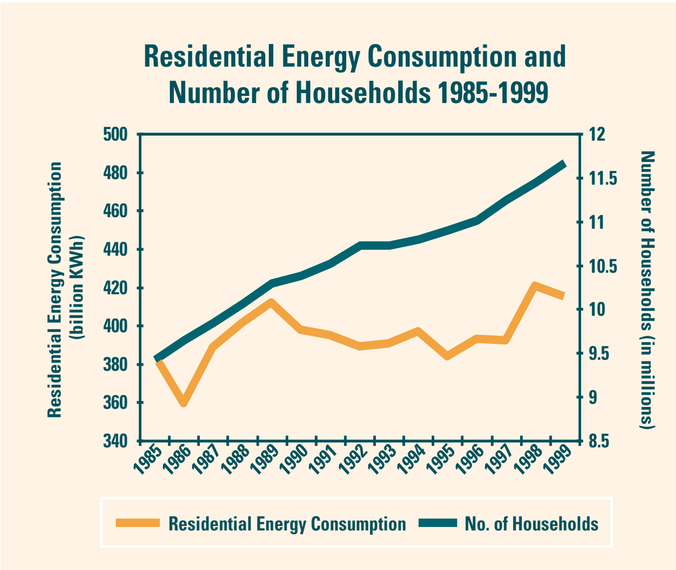
Over the last 15 years, the transportation sector has been the largest consumer of energy. Consumption by this sector includes energy used to power motor vehicles, airplanes and boats.

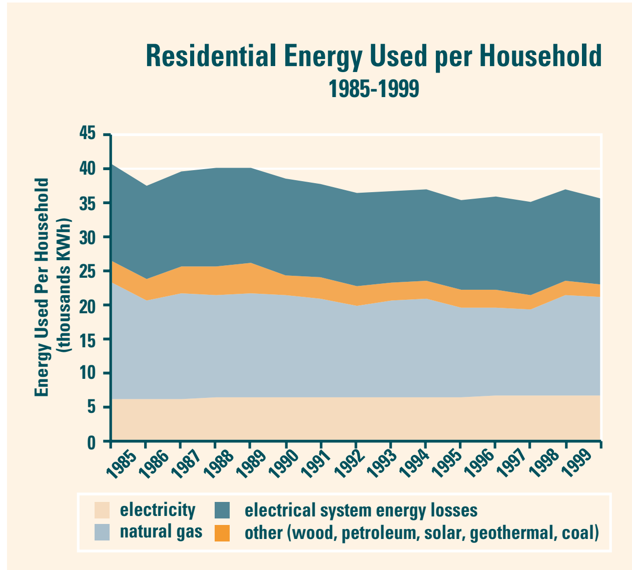
Nearly 60 percent of the transportation energy consumption is the result of combustion of gasoline in cars and light-duty trucks.

The transportation and industrial sectors together were responsible for about 85 percent of the increase in energy consumption from 1985 to 1999.

Reference:

U.S. Department of Energy, Energy Information Administration. *State Energy Data Report 1999*. Posted at: www.eia.doe.gov





From 1985 to 1999, residential energy consumption has fluctuated somewhat but increased overall by about 8-9 percent. In the meantime, the number of households has steadily increased by almost 2 million, resulting in an increase of 18 percent. The slower increase in residential energy consumption relative to the increase in the number of households has, in fact, resulted in a slight decrease in the energy used per household during this period. Better home insulation and more energy-efficient appliances are some reasons for the increased energy efficiency.

The fluctuations in yearly residential energy consumption are, to some extent, the result of weather conditions (i.e., below average winter temperatures for a given year could result in increased energy consumption in the form of greater home heating).

There are some large forms of energy loss that are unfamiliar to most Californians, including those associated with the generation, transmission, and distribution of electricity to households (plus plant use and unaccounted-for electrical energy system losses). These electrical energy losses account for roughly 70-75 percent of total household electrical energy use.

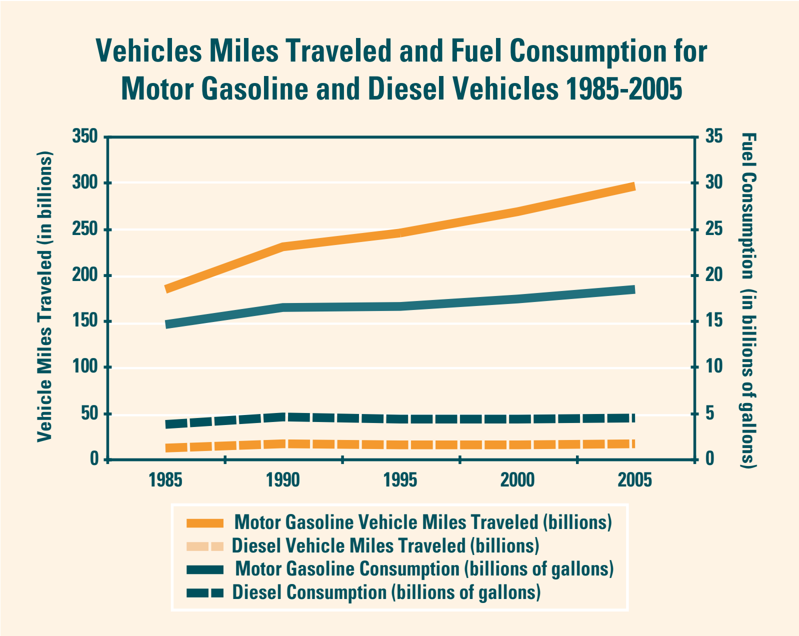
References:

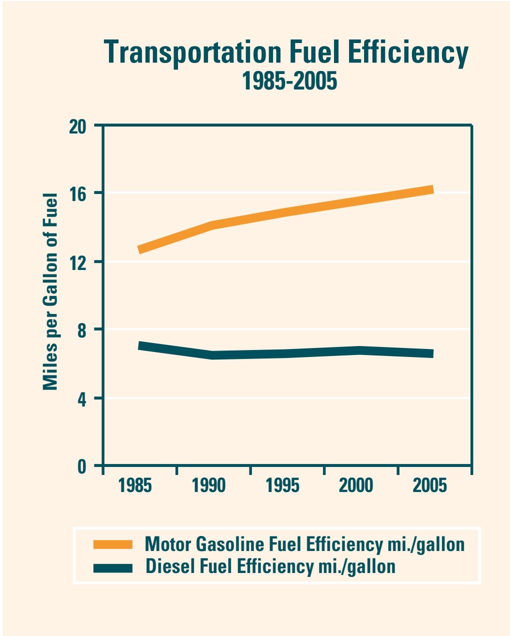
U.S. Department of Energy, Energy Information Administration. *State Energy Data Report 1999.* Posted at: www.eia.doe.gov

U.S. Census Bureau. *Intercensal Estimates of Total Households by State.* Population Division, Population Estimates Program. Posted at: www.census.gov/population/estimates/housing/sthuhh7.txt

Transportation

Transportation has both direct and indirect effects on the resources and environmental conditions of the state. Some of these effects result from vehicle emissions, use and handing of fuels, construction of roads, and energy utilization.





California's roads see increasingly more traffic per year, as reflected by the trend in vehicle miles traveled (VMT) for gasoline-fueled vehicles. This trend is expected to continue through 2005 and beyond. Motor vehicle gasoline consumption, however, has not increased at the same rate as VMT. Thus, the average transportation fuel efficiency for motor gasoline vehicles has improved from 12.6 miles per gallon in 1985, to 15.5 miles per gallon in 2000.

The steady increase in fuel efficiency is occurring in spite of the increased popularity of sport utility vehicles, minivans, and light-duty trucks through the 1990's, all of which provide poorer gas mileage relative to smaller passenger vehicles. The increasing fuel efficiency is due primarily to improved emission standards for California vehicles and the continual retirement of older, less fuel-efficient cars from California roads.

Diesel-fueled vehicles represent about 12 percent of total fuel consumption in 2000. Heavy-duty trucks (large commercial vehicles and big rig trucks) are the primary consumers of diesel fuel, making up roughly 87 percent of all diesel vehicles. The fuel efficiency for diesel vehicles remains relatively unchanged since 1985 and is not expected to change significantly through 2005.

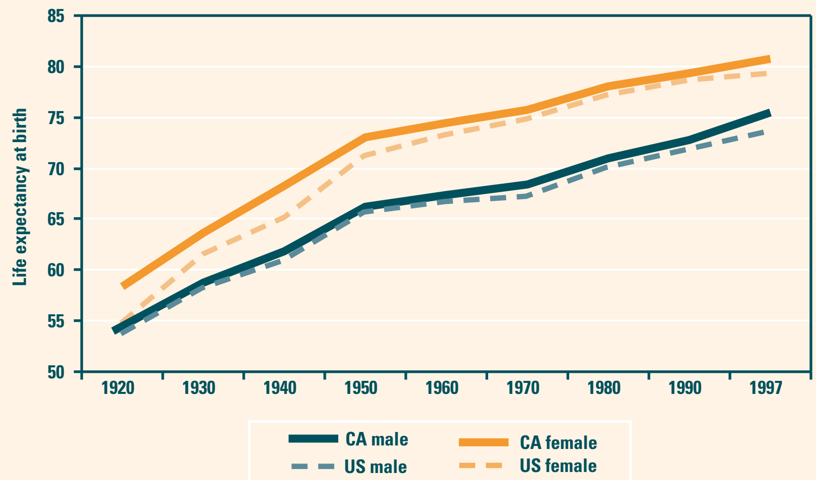
Reference:

California Air Resources Board. On Road Motor Vehicle Inventory, EMFAC2000, Version 2.02, January 2001. Sacramento, California.

Human Health

Life expectancy and statistics on the leading causes of death in California provide some insight into general human health. Changes in life expectancy are an important indicator of overall health of a population and reflect a society's ability to control and prevent serious diseases or other potentially life-threatening conditions.

Life Expectancy at Birth for U.S. and California
1920-1997



In 1997, life expectancy at birth was 75.5 years for California males and 80.7 years for California females. California males' life expectancy in 1997 was 1.9 years more than that of U.S. males. California females' life expectancy in 1997 was 1.3 years more than that of U.S. females.

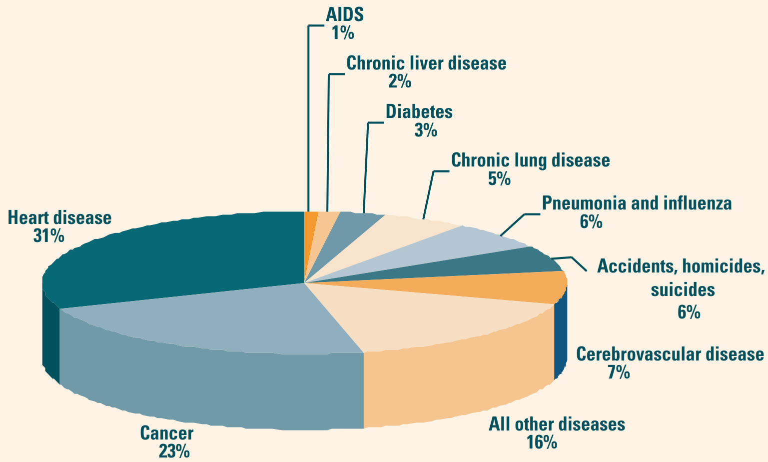
Primarily through improved public health practices and advances in medicine, from 1920 to 1997, life expectancy at birth has increased 21 years for California males and 22.3 years for California females. The same improvement in life expectancy is also evident at the national level.

References:

Centers for Disease Control and Prevention. *Estimated life expectancy at birth in years, by race and sex: Death-registration states, 1900-28, and United States, 1929-97*. National Vital Statistics Report, 47(28). December 13, 1999. Posted at: www.cdc.gov/nchs/fastats/pdf/47_28t12.pdf

California Department of Health Services. Life expectancy at birth and average number of years of life remaining at age 65 by selected years and sex, California, 1919-1920, 1929-1931, 1939-1941, 1950, 1960, 1970, 1980, 1990-1999 (preliminary). Reports posted at: www.dhs.ca.gov/services/dhs-statistics.htm

Leading Causes of Death in California, 1998

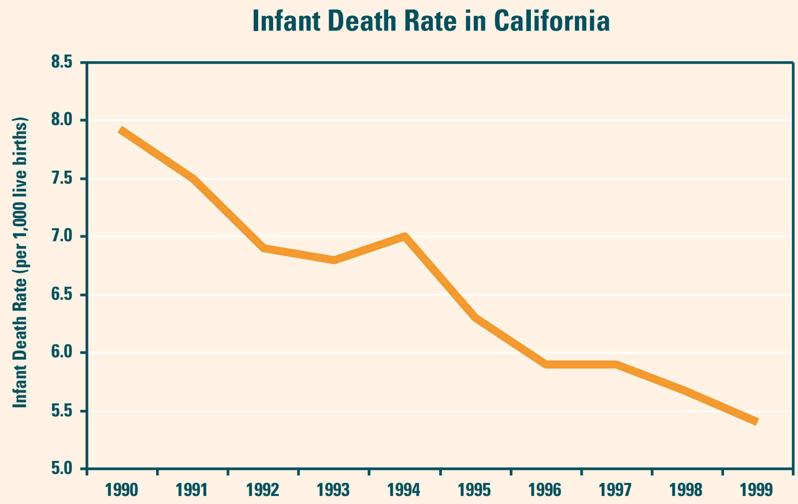


Cancer is the second leading cause of death in California (and in the U.S.), causing more than 50,000 deaths each year. Smoking, poor diet, and obesity are primary risk factors for diseases such as cancer, heart disease, cerebrovascular disease, chronic lung disease, and diabetes.

References:

California Department of Health Services, Center for Health Statistics. *California Cancer Facts and Figures 2001*, American Cancer Society. Posted at: www.ccrcal.org/PDF%20Files/Min2001.pdf

BACKGROUND



The infant death rate (deaths among infants under one year old per 1,000 live births) continues to be one of the most widely used indicators of the overall health status of a community.

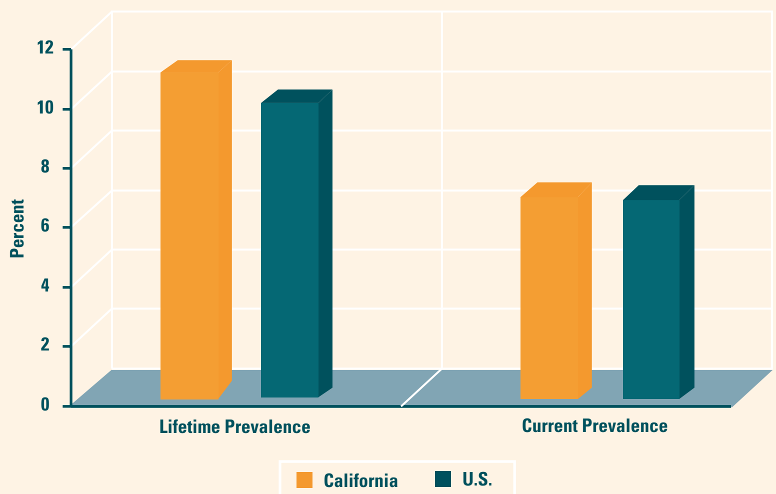
In 1999, California had the lowest infant death rate ever recorded for the state. There were a total of 2,787 infant deaths and 518,073 live births among California residents, for an infant death rate of 5.4 per 1,000 live births. Advances in medicine that increased survival rates among premature infants, and the success in informing parents how to prevent Sudden Infant Death Syndrome (SIDS) are some possible reasons for the lowering infant death rate.

The 1999 infant death rate decreased 31.6 percent from the 1990 rate of 7.9 per 1,000 live births. California's infant death rate for 1999 was lower than the U.S. preliminary estimate for infant death rate of 6.9 per 1,000 live births.

Reference:
California Department of Health Services, Center for Health Statistics. California's infant death rate 1999: Data summary. Report Register No. DS00-01002 (January 2001).

Asthma is one of the most common chronic diseases in the U.S. Until recently, state-specific data on asthma prevalence were not available. This indicator summarizes California and total U.S. asthma prevalence data collected from the Behavioral Risk Factor Surveillance System survey. The year 2000 was the first year in which state-specific asthma prevalence data became available. Continued use of this survey will allow state health departments to monitor trends in asthma prevalence and to provide data to guide asthma management.

Self-Reported Asthma Prevalence Among Adults
California and United States, 2000



Two asthma case definitions were constructed for this survey. In the survey, lifetime asthma was determined by a "yes" answer to "Have you ever been told by a doctor that you have asthma?" Current asthma was determined by a "yes" answer to the same question, as well as to the question, "Do you still have asthma?"

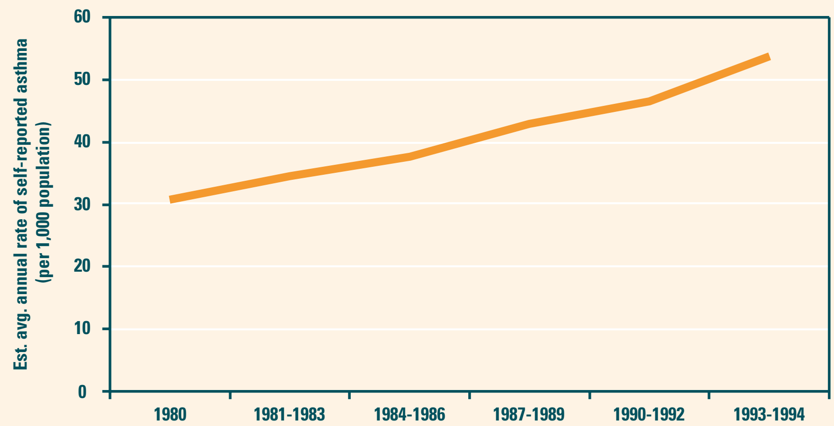
During 2000, the California and overall U.S. lifetime asthma prevalence was 11.5 and 10.5 percent, respectively. Current asthma prevalence in California and the U.S. was nearly the same at 7.3 and 7.2 percent, respectively. Total number of California respondents for lifetime and current asthma was 3,905 and 3,898, respectively. Total number of U.S. respondents for lifetime and current asthma was 182,293 and 181,914, respectively.

Other overall U.S. asthma prevalence data noted that current asthma was higher among blacks (8.5 percent) than whites (7.1 percent) and persons of other race/ethnicity (5.6 percent). The prevalence of current asthma decreased with increasing family income (from 9.8 percent among persons with family incomes of less than $15,000 to 5.9 percent among persons with family incomes of $75,000 or higher). Women had higher rates of current asthma than men both in California (9.0 percent versus 5.6 percent) and overall (9.1 percent versus 5.1 percent).

Reference:

Centers for Disease Control and Prevention. *Self-reported asthma prevalence among adults—United States, 2000*. MMWR Weekly 50(32);682-6. August 17, 2001. Posted at: www.cdc.gov/mmwr/preview/mmwrhtml/mm5032a3.htm

Available surveillance data indicate that the asthma prevalence rates have been increasing both in California and nationally. In response to this alarming trend, California has set-up a comprehensive surveillance system, as shown in the previous indicator, which measures asthma trends at the state level.



A yearly survey conducted by the National Center for Health Statistics among 20,000 U.S. persons shows that asthma prevalence increased by 75 percent from 1980 to 1994. This increasing trend was evident among all races, both sexes, and all age groups. The most substantial increase occurred among children aged 0-4 years (up 160 percent from 22.2 per 1,000 to 57.8 per 1,000), and persons aged 5-14 years (up 74 percent from 42.8 per 1,000 to 74.4 per 1,000).

In California, the limited data available indicated that the occurrence, trends, and impacts of asthma tend to agree with the nationwide trends. In 1984, 7.6 percent of adults reported through the statewide Behavioral Risk Factor Survey that they have had asthma at some point. This figure rose to 12.1 percent in 1996, a 60 percent increase.

A few evaluations have included consideration of whether the increase in asthma prevalence reflects a true increase in disease occurrence or merely a trend in the willingness of physicians or patients to diagnose/report the disease. The results suggest there is indeed a real increase in asthma cases in both California and the U.S.

Based on a national estimate of asthma prevalence, 1.8 million Californians have asthma, including half a million children. As one of the most common chronic diseases in children, asthma is a leading cause of school absences and hospital admissions for children.

The majority of asthma hospitalizations in California are thought to be preventable. Thus, the $350 million direct costs associated with these events are likely to be preventable as well.

References:

Mannino DM, Homa DM, Pertowski CA, Ashizawa A, Nixon LL, Johnson CA, Ball LB, Jack, E, Kang, and DS. 1998. *Surveillance for asthma – United States, 1960-1995*. MMWR 47(SS-1); 1-28. Posted at: www.cdc.gov/mmwr/preview/mmwrhtml/00052262.htm

California Department of Health Services, Environmental Health Investigations Branch.
Asthma in California: Background of site/study. Posted at: www.dhs.cahwnet.gov/ps/deodc/ehib/ehib2/topics/asthma.html

Water Supply

This table presents estimated water supplies for 1995 and the projected supplies for 2020 as reported in the California Water Plan Update 1998 (Bulletin 160-98). It does not estimate the entire State's water supply, but rather a portion of the water runoff as well as other water sources delivered to meet for urban, agricultural and environmental uses.

California Water Supplies with Existing Facilities and Programs[a] (taf)[b]

Supply	1995		2020	
	Average	Drought	Average	Drought
Surface				
Central Valley SProject	7,000	4,820	7,350	4,890
State Water Project	3,130	2,060	3,440	2,390
Other Federal Projects	910	690	910	680
Colorado River	5,180	5,230	4,400	4,400
Local	11,050	8,480	11,070	8,740
Required Environmental Flow	31,370	16,640	31,370	16,640
Reapplied	6,440	5,600	6,450	5,580
Groundwater[c]	12,490	15,780	12,680	16,010
Recycled and Desalted	320	330	420	420
Total (rounded)	**77,900**	**59,640**	**78,080**	**59,750**

a Bulletin 160-98 presents water supply data as applied water, rather than net water. See reference below for additional information
b Thousand acre feet, rounded
c Excludes groundwater overdraft

The table shows California's estimated water supply, for average and drought years under 1995 and 2020 levels of development, with existing facilities and programs. Surface water includes developed supplies from federal, state and local projects. Required environmental flows are comprised of undeveloped supplies designated for wild and scenic rivers, supplies used for instream flow requirements, and supplies used for Bay-Delta water quality and outflow requirements. Finally, surface water includes supplies available for reapplication downstream. In an average year, 30 percent of California's urban and agricultural applied water is provided by ground water extraction. In drought years when surface water supplies are reduced, ground water supports an even larger percentage of use. Recycled water plays an important role in lessening the need for new water supplies, although it does not provide a new source of water. Similarly, California's existing desalting plants use brackish groundwater, wastewater and seawater to provide additional water particularly for coastal communities with limited existing water supplies.

Reference:

Department of Water Resources. The California Water Plan Update, Bulletin 160-98. Posted at: www.waterplan.water.ca.gov

Land Use

The land use impacts of population growth are many. Population growth affects the amount of habitat available for wildlife, introduces stresses on many wildlife species, interrupts many ecological processes such as water cycling, complicates fire protection and forest management activities, and reduces open space aesthetics.

This indicator provides a context for the Land Cover and Habitat Quality and Quantity indicators within the Ecosystem Health Section, which measure the changing landbase of California's natural ecosystems.

Before 1940, development comprised merely 3 percent (1.5 million acres) of all private lands. By 1990, development had occurred on over 15 percent (8.4 million acres) of all private lands.

Since 1940, development has impacted 7 million acres or 13 percent of the state's undeveloped private land. During this period, agricultural land was the largest recipient of growth, with development of over 26 percent (3.1 million acres) of the 1940 agriculture land base. By 1990, natural ecosystems (forest, shrub, grass, desert, barren) had lost nearly 4 million acres or 7 percent of the undeveloped private land of 1940.

Urbanization is defined as a density of one or more houses per 20 acres. This definition is not a typical urbanization density (usually one or more units per acre), but is used to better represent the associated impacts of urbanization on ecosystems.

Information should be used at a broad scale as each block of urbanization shown represents 9.65 square miles and density is averaged within that block.

Progression of Development of California's Land, 1940 to 1990

See full color map on page 262

Reference:
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Air Quality

Introduction

Air pollution is one of the major environmental challenges modern society faces. Human health effects can range from lung irritation to cancer and premature death, while ecological effects include damage to crops, forests, and rangeland, soil acidification, and contamination of water bodies. Air pollution consistently ranks high among public concerns in California, and control efforts have been given a high priority in recent decades. Sources of air pollution include automobiles, trucks, and other on- and off-road mobile sources; paints, consumer products, pesticides, and other widespread sources; and power plants, refineries, and other large "point sources." While technological advances and regulatory strategies have yielded significantly cleaner air over the past decades, increases in population and automobile use provide challenges to continued air quality improvements.

Air quality indicators reflect pressures on the environment (emissions), state of the environment (ambient concentrations), and potential health risk posed by air pollutants. This succinct set of indicators, considered collectively, is intended to provide an understanding of the state's air quality, sources of air pollution, and potential effects on the public. Indicators for ecological effects of air pollution and global climate change are addressed in other sections of this report.

Air Quality Indicators

Criteria Air Pollutants

Ozone

Days with unhealthy levels of ozone pollution (Type I)

Peak 1-hour ozone concentration (Type I)

Exposure to unhealthy ozone levels in the South Coast air basin (Type I)

Emissions of ozone precursors —Volatile organic compounds + Oxides of nitrogen (Type I)

Particulate matter (PM10)

Days with unhealthy levels of inhalable PM10 (Type I)

Peak 24-hour PM10 concentration (Type I)

Annual PM10 concentration (Type I)

Total primary and precursor PM10 emissions (Type II)

Carbon monoxide

Days with unhealthy levels of carbon monoxide (Type I)

Peak 8-hour carbon monoxide concentration (Type I)

Carbon monoxide emissions (Type I)

Toxic air contaminants (TACs)

Total emissions of TACs (Type II)

Community-based cancer risk from exposure to TACs (Type II)

Cumulative exposure to TACs that may pose chronic or acute health risks (Type II)

Visibility

Visibility on an average summer and winter day and in California national parks and wilderness areas (Type II)

Indoor air quality

Household exposure of children to environmental tobacco smoke (Type I)

Indoor exposure to formaldehyde (Type III)

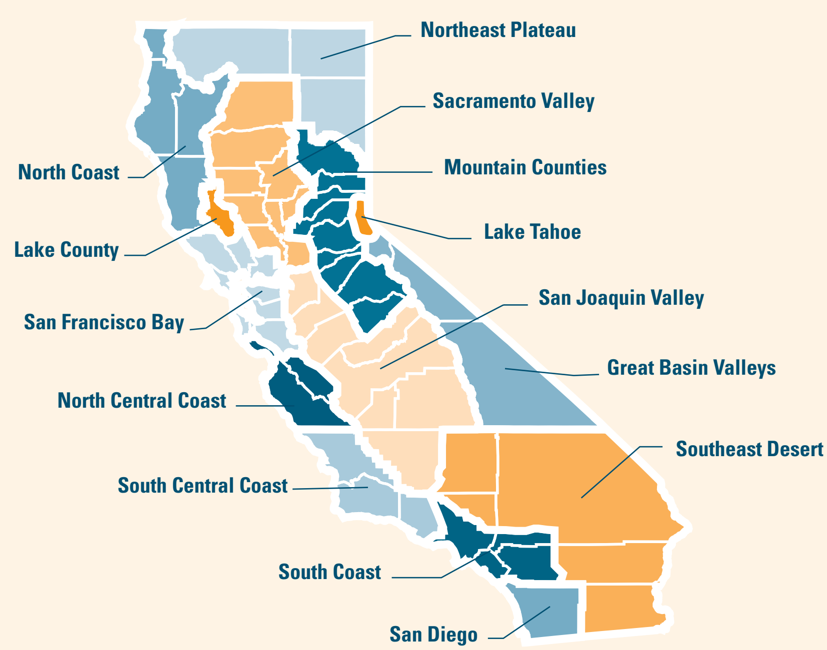
Issue 1: Criteria Air Pollution

Shortly after its creation in 1970, the U.S. Environmental Protection Agency (U.S. EPA) established health-based National Ambient Air Quality Standards (NAAQS) for six common "criteria" air pollutants. These standards cover carbon monoxide, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM). California also sets its own ambient air quality standards that are generally more health-protective than NAAQS for most pollutants.

Indicators have been selected only for criteria pollutants for which one or more California air basins are in non-attainment of – that is, air concentrations of a criteria air pollutant are at levels equal to or exceeding — a state or federal air quality standard. The most health protective state or federal standard has generally been chosen as an indicator benchmark. For example, the number of days above the state 8-hour standard for carbon monoxide is generally more stringent than the state or federal 1-hour standard, because an area in attainment of the state 8-hour standard usually also attains the other state and federal carbon monoxide standards.

As a result of technological advances and implementation of control measures over the past three decades, emissions and ambient levels of criteria pollutants have declined steadily throughout most of the state. While all of California now attains the state and federal nitrogen dioxide, sulfur dioxide, and lead standards, most Californians still live in regions with unhealthy levels of ozone,

California Air Basins



particulate matter, or carbon monoxide. The California map on page 28 divides the state into the major air basins. The five main air basins that face the greatest challenge in controlling criteria air pollutants are the Sacramento Valley, San Joaquin Valley, San Francisco Bay Area, South Coast (including Los Angeles), and San Diego. These five air basins will be highlighted in most of the air quality indicator descriptions.

Ozone:

Ground-level ozone is a major component of urban and regional smog. Ozone is not directly emitted, but is formed when volatile organic compounds (VOCs) and oxides of nitrogen (NOx) emissions react in the presence of sunlight. Ozone is a strong irritant, which can reduce lung function and aggravate asthma as well as lung diseases such as bronchitis and emphysema. Repeated short-term ozone exposure may harm children's developing lungs and lead to reduced lung function in adulthood. In adults, ozone exposure may accelerate the natural decline in lung function that occurs as part of the normal aging process. While ozone levels have generally declined in recent decades, the state's major urban areas and the Central Valley still violate the state and federal ozone standards.

Indicators

Days with unhealthy levels of ozone pollution (Type I)

Peak 1-hour ozone concentration (Type I)

Exposure to unhealthy ozone levels in the South Coast air basin (Type I)

Emissions of ozone precursors (VOC + NOx) (Type I)

Inhalable Particulate Matter (PM10):

Particulate matter with an aerodynamic diameter of 10 microns or less (PM10) is a mixture of substances that includes elements such as carbon, lead, and nickel; compounds such as nitrates, organic compounds, and sulfates; and complex mixtures such as diesel exhaust and soil. Particulate matter may occur as solid particles or liquid droplets. Primary particles are emitted directly into the atmosphere, while secondary particles result from gases that are transformed into particles in the atmosphere.

When inhaled, particles can increase the number and severity of asthma attacks and cause or aggravate bronchitis and other lung diseases. Community health studies also link particle exposure to the premature death of people who already have heart and lung disease, especially the elderly. Airborne particles are a primary component of haze that obscures visibility in cities, rural communities, and scenic parks.

Air monitors, designed to sample PM10 concentrations, are concentrated in regions where exceedances are most likely to occur. If any one of those 154+ monitors records a 24-hour average concentration over the state standard (50 micrograms per cubic meter [$\mu g/m^3$]), then the air basin in which that monitor is located exceeds the PM10 standard for that day. While PM10 levels have declined in recent decades, the South Coast, Central Valley, Salton Sea, and Great Basin continue to violate the federal 24-hour standard (150 $\mu g/m^3$) while most of the state is in violation of the stricter state standard.

Indicators

Days with unhealthy levels of inhalable particulate matter (PM10) (Type I)

Peak 24-hour PM10 concentration (Type I)

Annual PM10 concentration (Type I)

Total primary and precursor PM10 emissions (Type II)

Indicators

Days with unhealthy levels of carbon monoxide (Type I)

Peak 8-hour carbon monoxide concentration (Type I)

Carbon monoxide emissions (Type I)

Carbon monoxide:

Carbon monoxide is an odorless, colorless gas that is formed when fuels are incompletely burned. Motor vehicles, especially those that are poorly maintained, are the primary sources of ambient carbon monoxide in populated areas. When inhaled, carbon monoxide molecules bond with hemoglobin molecules in the blood, preventing them from carrying oxygen throughout the body. Reduced oxygen-carrying capacity is especially hazardous for those with heart disease or limited lung function.

Air monitors designed to measure carbon monoxide concentrations are spread throughout California. These air monitors are located in places where carbon monoxide exceedances are most likely to occur. Carbon monoxide levels have generally declined in recent decades, and only Los Angeles and Calexico still violate the federal or state standard for carbon monoxide.

Indicators

Total emissions of toxic air contaminants (Type II)

Community-based cancer risk from exposure to TACs (Type II)

Cumulative exposure to toxic air contaminants that may pose chronic or acute health risks (Type II)

Issue 2: Toxic Air Contaminants (TACs)

Toxic air contaminants are air pollutants that may cause serious adverse human health or environmental effects. TACs may exist as particulate matter or in gaseous form, and include metals, gases adsorbed onto particles, and certain vapors from fuels and other sources. Examples of TACs include benzene, dioxins, 1-3 butadiene, and particulate emissions from diesel-fueled engines (diesel PM). TACs exhibit a wide range of ambient concentrations, toxicities, and exposure-response relationships. Depending on the TAC, exposure to these pollutants can result in cancer, poisoning, eye, nasal, and skin irritation, and/or rapid onset of sickness, such as nausea or difficulty in breathing. Other effects may include immunological, neurological, reproductive, developmental, and respiratory problems. About 88 percent of the overall estimated cancer risk from air toxics results from diesel PM (70 percent), benzene (10 percent) and 1,3 butadiene (8 percent) - all substances that are derived primarily from the emission or combustion of petroleum products. For more information on TACs, visit: www.arb.ca.gov/toxics/tac/tac.htm

Extensive research is needed to better understand the cumulative effects of multiple air toxics. This is of particular concern in urban areas where residents are exposed to emissions from multiple sources. The California Air Resources Board (ARB) has made it a priority to assess and reduce risk at the community level to ensure that all Californians, including children, the elderly, and environmental justice communities, can breathe clean, healthful air. For more information on ARB's environmental justice efforts, visit: arbis.arb.ca.gov/ch/ej.htm

Issue 3: Visibility

The same particles and gases linked to serious health and environmental effects can also significantly affect visibility. The scattering and absorption of light by particles and gases in the atmosphere limit the distance we can see, and degrade visual clarity and contrast. Both primary emissions and secondary formation of particles contribute to visibility impairment. Primary particles, such as elemental carbon from diesel and wood combustion, or dust from natural sources, are emitted directly into the atmosphere. Secondary particles that are formed in the atmosphere from gaseous emissions include nitrates from NOx emissions, sulfates from SO_2 emissions, and organic carbon particles formed from condensed hydrocarbon emissions.

Indicators

Visibility on an average summer and winter day and in California national parks and wilderness areas (Type II)

Issue 4: Indoor Air Quality

Studies of human exposure to air pollutants indicate that indoor levels of many air pollutants may be two to five times (and occasionally more than 100 times) higher than outdoor levels. This is a concern since people — in particular infants, young children, and the elderly who are more susceptible to adverse effects from pollutants — spend, on average, 90 percent of their time indoors. Over the past several decades, exposure to indoor air pollutants is believed to have increased due to a variety of factors, including the increased use of synthetic building materials and furnishings; the increased use of personal care products, pesticides, and household cleaners; the construction of more tightly sealed buildings; and reduced ventilation rates to save energy.

Environmental tobacco smoke (ETS), also known as secondhand smoke, is a major concern in indoor environments. ETS is of particular concern for children, having been associated with increased occurrence of childhood asthma, lower respiratory tract infections, low birth weight, and sudden infant death syndrome. Various tobacco-related health programs have been introduced since the early 1990s to increase the awareness of ETS dangers in the home. In California, a yearly statewide survey is conducted by the Department of Health Services to make a qualitative assessment of ETS exposure in households with children.

Another major indoor air pollutant of concern is formaldehyde. A primary source of this volatile organic compound (VOC) is pressed wood products. Formaldehyde is an irritant to the eyes, nose, throat and lungs, and long-term exposure may cause cancer. An indoor air indicator for this VOC would help determine the effectiveness of programs currently being put in place by Cal/EPA to reduce formaldehyde from pressed wood products, and to identify if other actions need to be taken.

Indicators

Household exposure of children to environmental tobacco smoke (Type I)

Indoor exposure to formaldehyde (Type III)

ETS and formaldehyde are just two of many potentially hazardous substances that can be found in indoor air. Other indoor air pollutants include other VOCs (such as tetrachloroethylene, trichloroethylene, chloroform, benzene, styrene, p-dichorobenzene, etc.), carbon monoxide, nitrogen dioxide, radon, particulate matter, lead, mold spores, and sources of allergens such as dust mite droppings, cat and dog dander, and cockroaches. Clearly, a complete indicator system would need to cover all classes of indoor air pollutants, not just ETS and formaldehyde.

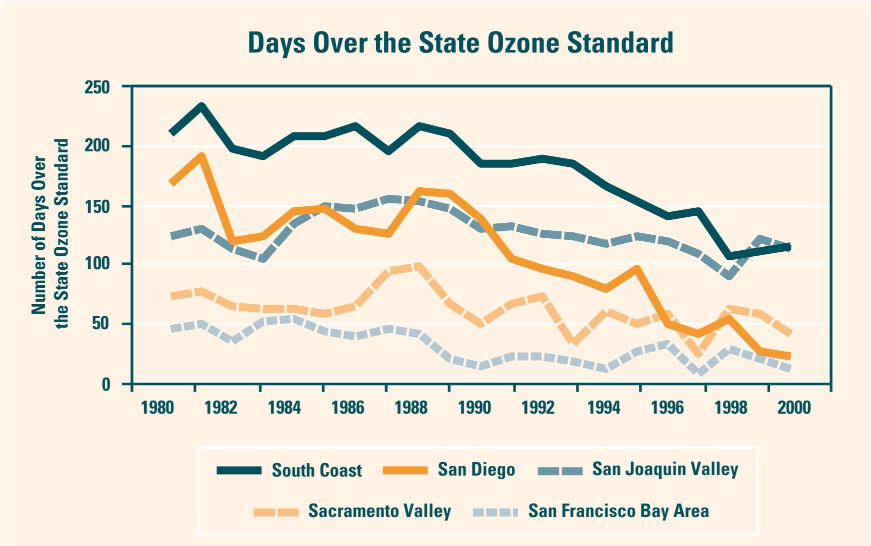
Currently, there are no programs in California that systematically collect quantitative data on people's exposures to indoor air pollutants in schools, public buildings, and homes. Ongoing monitoring data on indoor pollutants that are indicative of general indoor pollution levels could go far in improving our understanding of the scope and extent of the problem. This would facilitate identification of effective measures to reduce and prevent indoor pollution by tracking pollution levels before and after the implementation of preventative measures.

Days with Unhealthy Levels of Ozone

The number of days over the state 1-hour standard vary by region and are declining in most of California.

Type I

Level 4
Goal 1



What is the indicator showing?

The number of days in California with unhealthy levels of ozone has decreased substantially over the past two decades. Decreases were modest during the 1980s but accelerated during the 1990s.

Why is the indicator important?

This indicator tracks the number of days in which each California air basin exceeds the state 1-hour ozone standard of 0.09 parts per million (ppm), and illustrates the chronic nature of the public's exposure to ozone. Scientific studies suggest that exposure above this level may impair breathing and aggravate asthma and lung diseases such as bronchitis and emphysema. Intermittent exposure to high levels of ozone may harm children's developing lungs and lead to reduced lung function in adulthood. In adults, ozone exposure may accelerate the natural decline in lung function that occurs as part of the normal aging process.

Attainment of ozone standards requires that ozone concentrations rarely exceed a threshold level that can cause harmful effects. For example, when on average only one day per year is above California's 1-hour ozone standard, the state standard will be attained. The vast majority of California (with the exception of some northern counties and undesignated rural areas) does not attain this state standard.

What factors influence this indicator?

Ozone levels depend upon emissions of ozone precursors [volatile organic compounds (VOCs) and oxides of nitrogen (NOx)] and weather. VOCs and NOx are emitted by a wide range of sources, including: automobiles, trucks, and other on- and off-road mobile sources, paints, solvents, pesticides, and other widespread sources; and power plants, refineries, and other large "point sources." Reductions from most sources have occurred due to technological improvements. Tighter emission standards for new motor vehicles, for example, provide significant reductions as older, dirtier vehicles are retired.

While efforts to reduce precursor emissions have proven effective in reducing the number of unhealthy ozone days, particularly in the 1990s, weather plays a greater role than precursor reductions on a year-to-year basis. For example, a hot summer day with stagnant air conditions will greatly increase the chance of unhealthy ozone levels. This indicator is also influenced by the number and location of air quality monitors (see below).

Technical Considerations:

Data Characteristics

Data needed to determine the number of days with unhealthy levels of ozone is readily available from existing networks of air quality monitors in California. More than 200 ozone monitors have been placed in California, primarily in urban areas, to measure ozone concentrations hourly throughout the year or during the summer ozone season. The measurement methods are standard (ultraviolet absorption) and highly precise. Locations for most ozone monitors are selected to secure representative data on an "urban" scale (4 to 50 kilometers). The data are maintained on the Aerometric Data Analysis and Management (ADAM) System. These data satisfy rigorous criteria for quality assurance.

Strengths and Limitations of the Data

The number of days with unhealthy levels of ozone represents the chronic nature of unhealthy ozone levels in a region. This indicator can be used to approximate a region's status with respect to the 1-hour ozone standard. It can also be used to construct trends that may respond differently over time compared to other ozone indicators.

While the data indicate the number of times an area exceeds the state health-based ozone standard, it does not capture multiple exceedances in the same day, or the degree of each exceedance. In addition, although most air basins exceeding ozone standards have multiple monitoring stations, there is no mechanism for recording exceedances in non-monitored areas. Strategic monitor placement, however, allows for capturing of air quality measurements representative of an area since ozone is a regional pollutant and generally does not vary significantly over short distances. As emissions of VOCs and NOx decrease, this indicator should respond with reduced counts of days with unhealthy ozone.

Using readily available air quality data, this indicator can be reproduced easily.

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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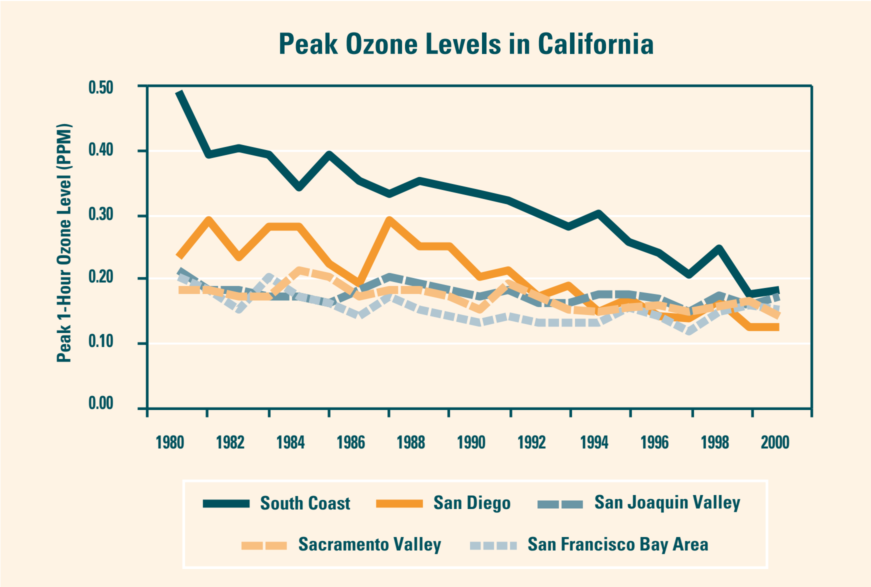
Peak 1-Hour Ozone Concentration

The highest 1-hour ozone concentration measured at most monitors in the state has declined.

Type I

Level 4
Goal 1



What is the indicator showing?

Peak ozone levels have been declining fastest in the air basins with the greatest air quality problems, including the South Coast (Los Angeles Basin) and San Diego air basins.

Why is the indicator important?

This indicator is the highest measured 1-hour concentration at any monitor within an air basin for a particular year. Thus, the indicator represents the "worst-case" for a 1-hour exposure to ozone in a specified region, and provides a view of the potential for acute adverse health impacts due to ozone exposure. The peak 1-hour ozone concentration has declined substantially in some major urban areas in California over the last 20 years. In the South Coast Air Basin, the peak 1-hour ozone concentration decreased more than 40 percent, from an average of 0.41 ppm in 1980-82, to 0.22 ppm in 1997-99.

What factors influence this indicator?

Ozone levels depend upon emissions of ozone precursors volatile organic compounds (VOCs) and nitrogen oxides (NOx) and weather. While efforts to reduce precursor emissions have proven effective in reducing peak ozone concentration, weather also impacts the efficiency with which VOCs and NOx produce ozone and the extent to which ozone is concentrated in or removed from an area. A hot, sunny day with stagnant air conditions will generally result in higher peak levels of ozone. This indicator is also influenced by the number and location of air quality monitors (see below).

Technical Considerations:

Data Characteristics

The peak 1-hour ozone concentration represents the "worst-case" for 1-hour exposures to ozone in a region. This indicator can be used to approximate a region's status with respect to a 1-hour ozone standard. It can also be used to construct trends for peak ozone concentrations that respond to changes in the emissions of VOCs and NOx. Using readily available air quality data, this indicator can be reproduced easily.

Strengths and Limitations of the Data

Data needed to determine the peak 1-hour ozone concentration are readily available from existing networks of air quality monitors in California. More than 200 ozone monitors in California measure ozone concentrations hourly throughout the year or during the high ozone season when the annual maximum occurs. The measurement methods are standard (ultraviolet absorption) and highly precise. Locations for most ozone monitors are selected to secure representative data on an "urban" scale (4 to 50 kilometers). The data are maintained on the Aerometric Data Analysis and Management (ADAM) System. These data satisfy rigorous criteria for quality assurance. This indicator can be easily scaled to represent a single monitoring location or to represent a regional or statewide maximum.

While the data indicate the highest measured ozone concentration in each basin, they do not capture the number of times people were exposed to unhealthy air, the number and extent of additional high ozone levels, or the damage inflicted on the people of California. In addition, although most air basins exceeding ozone standards have multiple monitoring stations, there is no mechanism for recording high ozone levels that may occur in non-monitored areas. Strategic monitor placement allows for capturing of air quality measurements representative of the area, however, since ozone is a regional pollutant and generally does not vary significantly over short distances.

References:

Statewide Ozone Data Summary (1980-1998). Posted at: www.arb.ca.gov/aqd/ozone/stateoz1.htm

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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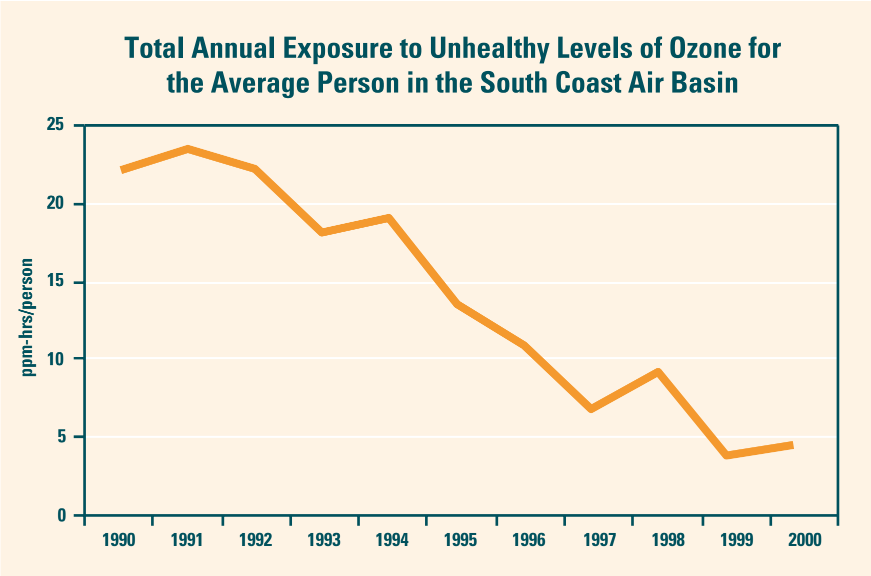
Exposure to Unhealthy Ozone Levels in the South Coast Air Basin

Since 1990, the total annual exposure to unhealthy ozone levels for the average person has dramatically declined.

Type I

Level 4
Goal 1



What is the indicator showing?

Exposure to unhealthy levels of ozone – based on duration of exposure and level of ozone pollution – has declined for the average resident in and around Los Angeles.

Why is this indicator important?

There are a number of ways to look at how ozone levels in California have changed over the years. Although simple indicators (such as those based on peak 1-hour levels or the number of days above the standard) are most commonly used, complex indicators that incorporate multiple parameters can offer additional insight concerning air quality. This is one such indicator. It reflects total annual (population-weighted) exposures to ozone. An "exposure" occurs when ozone concentrations exceed the 1-hour ozone standard, 0.09 parts per million (ppm). The indicator presents a composite of exposure at individual locations that have been weighted or adjusted to emphasize equally the exposure of each individual in an area. Both the magnitude and the duration of the average level of exposure to concentrations greater than the standard are incorporated into the indicator (ARB, 2001). For example, someone exposed to 0.15 ppm ozone (0.06 ppm above the state standard) for 220 hours would have an exposure level of 13.2 ppm-hrs (220 hrs x 0.06 ppm = 13.2 ppm-hrs). Ozone monitors located throughout the South Coast air basin, combined with air modeling techniques and census tract data, provide the data for determining the exposed population. In most years between 1990 and 2000, all residents of the South Coast air basin were exposed to ozone levels above the standard at some time during each year.

Some major urban areas in California have not seen the peak 1 hour ozone concentration decrease significantly over the last 20 years. Although attainment is based on peak concentrations (which provide an indication of the potential for acute adverse health impacts), total annual exposure provides an indication of the potential for chronic adverse health impacts. At this time, the South Coast is the only air basin in California for which total annual ozone exposure data have been developed. All five major air basins, including the South Coast, San Joaquin Valley, Sacramento Valley, San Francisco Bay Area, and San Diego air basins, will be included in this indicator in future updates.

What factors influence this indicator?

This indicator is dependent upon amount of time and the severity of unhealthy ozone pollution to which people are exposed. This is related to emissions of ozone precursors, as well as temperature and other weather considerations.

Technical Considerations:

Data Characteristics

The indicator is calculated using hourly ozone measurements that are above the level of the state standard. For each hour in the year, the concentration at the center of each census tract is estimated by interpolating the ozone concentrations at nearby monitors. Only monitors within a 50 kilometer radius of a census tract are included in the interpolation. Then, the increment between the estimated concentration and the state standard is computed (when the estimated concentration is lower than the state standard, the increment is set to zero). These increments are then weighted by population in each census tract and summed. The sum is divided by the total exposed population for that hour to obtain a population-weighted average. Finally, the hourly averages are summed for the year. Zero exposure areas (populated areas that had no exceedances for a given year) are not included in the exposure calculations because they dilute the real impact of the ozone concentrations that are above the state standard.

Strengths and Limitations of the Data

Air quality data needed for this indicator are readily available from existing networks of air quality monitors in California. More than 200 monitors in California measure ozone concentrations hourly throughout the year, or during the high ozone season when the exceedances of the standard occur. Population data (by census tract) from the 1990 U.S. Census are used. Updates for this indicator will apply more current census data.

Individuals are presumed to have been exposed to the concentrations measured by the ambient air quality monitoring network. However, daily activity patterns (for example, being inside a building or exercising outdoors) may diminish or increase actual exposures.

References:

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

Statewide Ozone Data Summary (1980-1998). Posted at: www.arb.ca.gov/aqd/ozone/stateoz1.htm

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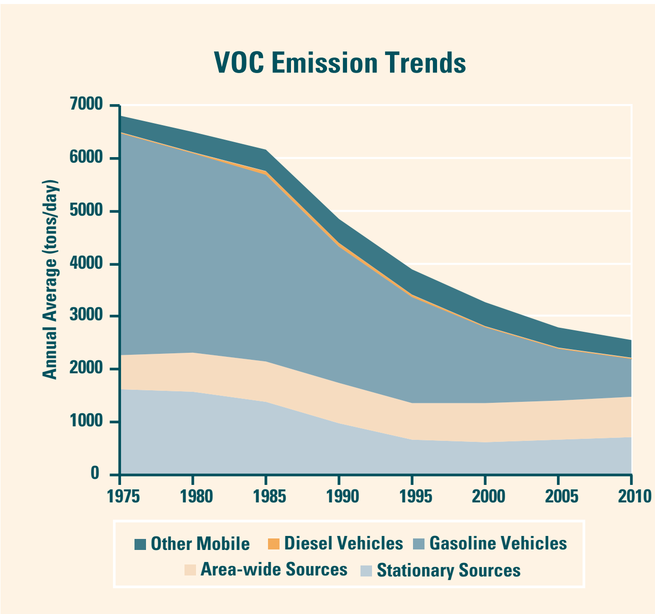
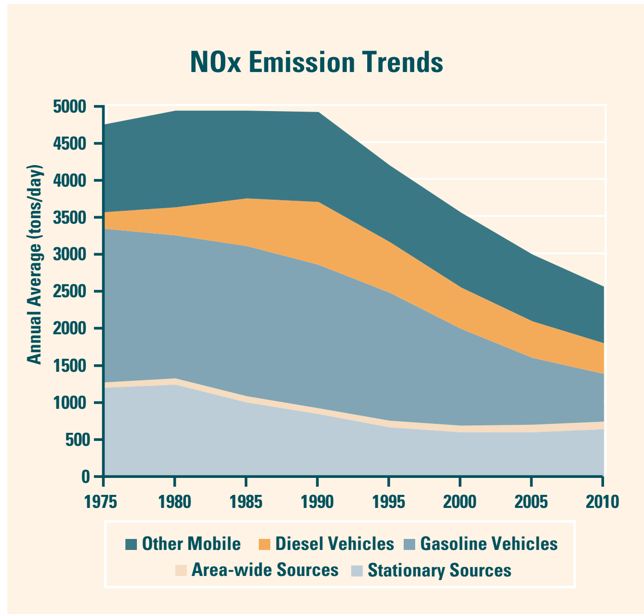
Emissions of Ozone Precursors – Volatile Organic Compounds (VOC) + Oxides of Nitrogen (NOx)

Statewide emissions have been declining.

Type I

Level 3
Goal 1





Why is the indicator important?

Volatile organic compounds (VOCs) and nitrogen oxides (NOx) react to form ozone in the atmosphere in the presence of sunlight. Emissions of these ozone precursors thus serve as an indicator of the ozone-forming potential in an area. VOC and NOx emissions are estimated as tons of emissions per day, averaged over an entire year.

What is the indicator showing?

Total emissions of both pollutants have been declining over the past 25 years. The greatest declines have resulted from reduction of gasoline vehicle emissions.

What factors influence this indicator?

Emissions come from four types of sources: stationary sources (including factories, power plants, and refineries), area-wide sources (including residential wood combustion, wildfires, and emissions from architectural coatings), mobile sources (including on- and off-road vehicles), and natural sources.

VOC emissions in California are projected to decrease by over 60 percent between 1975 and 2010, largely as a result of the state's on-road motor vehicle emission control program. This includes the use of improved evaporative emission control systems and computerized fuel injection and engine management systems to meet increasingly stringent California emission standards, cleaner gasoline, and the Smog Check program. VOC emissions from other mobile sources are projected to decline between 1995 and 2010 as more stringent emission standards are adopted and implemented. VOC emissions from diesel vehicles are very small relative to other sources of VOCs. Hence, the contribution from this source cannot be easily discerned in the VOC emissions trends graph. Substantial reductions have also been obtained for area-wide sources through the vapor recovery program for service stations, bulk plants and other fuel distribution operations. There are also on-going programs to reduce overall solvent VOC emissions from coatings, consumer products, cleaning and degreasing solvents, and other substances used within California.

NOx emission standards for on-road motor vehicles were introduced in 1971 and followed in later years by the implementation of more stringent standards and the introduction of three-way catalysts. NOx emissions from on-road motor vehicles have declined by over 30 percent from 1990 to 2000, and are projected to decrease by an additional 40 percent between 2000 and 2010. This has occurred as vehicles meeting more stringent emission standards enter the fleet, and all vehicles use cleaner burning gasoline and diesel fuel or alternative fuels. Stationary source NOx emissions dropped by over 40 percent between 1980 and 1995. This decrease has been largely due to a switch from fuel oil to natural gas and the implementation of combustion controls such as low-NOx burners for boilers and catalytic converters for both external and internal combustion stationary sources.

The decline in motor vehicle emissions has occurred in spite of the increase in vehicle miles traveled and increased fuel consumption in the state (see the transportation indicator in the background indicator section for more information).

Technical Considerations:

Data Characteristics

The relationship between VOC and NOx emissions and ozone formation is well known, and no other emissions indicator can more accurately reflect ozone forming potential. VOC and NOx emissions are most useful as indicators of multi-year trends in emissions. Emissions in past and future years are generated with the California Emission Forecasting System model, which uses the current year inventory as its input. This indicator is also useful in detecting regional differences in emission sources and patterns when emissions from various air basins are analyzed together.

Emissions from area-wide and natural sources are estimated using engineering methods on a rotating three-year basis; area-wide sources are adjusted with forecasting models in intervening years. Emissions from mobile sources are estimated with computer models yearly. Emissions from stationary sources are reported by air pollution control districts to the Air Resources Board on a yearly basis.

Strengths and Limitations of the Data

Local and regional air pollution control districts report emissions data for stationary sources to the Air Resources Board. Although some districts update their data yearly, others have not updated their emissions data for many years. Many area-wide source estimation methodologies are based on old data and are adjusted yearly with the use of surrogates. Total emissions of VOCs and NOx are estimated, not measured, using computer models.

VOC and NOx emissions data are heavily dependant on methodologies and models that may change from year to year. Because improvements in estimation methodologies or development of methodologies for previously uninventoried sources may result in misleading changes in emission levels between years, emissions are backcasted or forecasted based on growth and control data so that the inventory reflects consistent methodologies across trend years.

The photochemical relationship between VOCs and NOx is very complex, and occasionally increases in one pollutant can result in decreases in ozone formation. VOC and NOx emissions are not an exact predictor of actual ozone levels because ozone concentration is dependent on many other independent factors, including the ratio of VOCs to NOx, meteorology, climate, topography, and time of year. However, VOC and NOx emissions are excellent indicators of ozone forming potential, especially when combined with knowledge of other factors.

References:

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

California Air Resources Board. *Emission Inventory Procedural Manual, Volumes I-V*. 1997.

California Air Resources Board, Emission Inventory Web Page, Posted at: www.arb.ca.gov/emisinv/eib.htm

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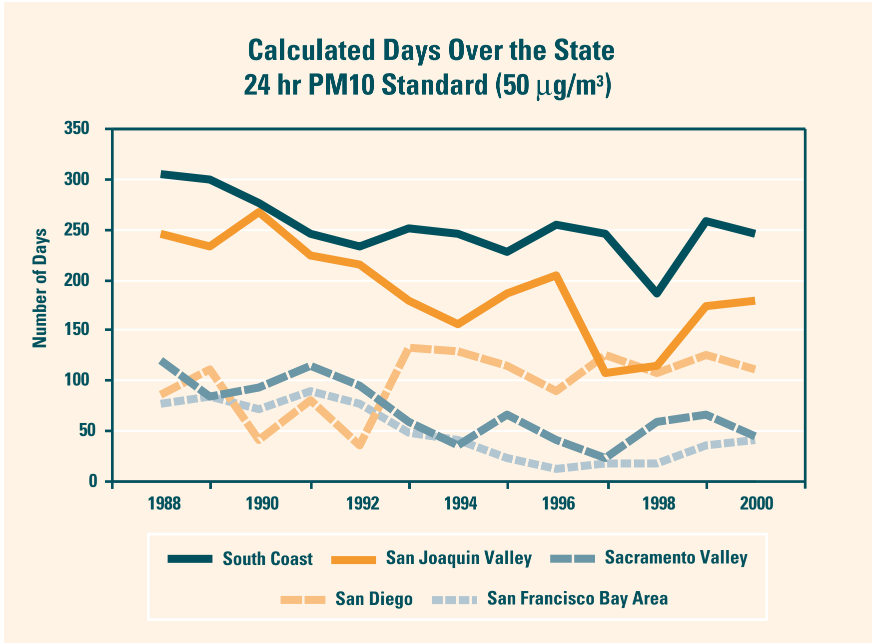
Type I

Level 4
Goal 1

Days with Unhealthy Levels of Inhalable Particulate Matter (PM10)

Exposure to PM has declined or remained stable in most regions of the state.



What is the indicator showing?

Most of the major air basins have shown a moderate decline in number of days over the PM10 standard.

Why is the indicator important?

PM10 particles deposit deeply in the lungs and may contain substances that are particularly harmful to human health. Particle deposition in the lung is highly dependent on particle diameter, as smaller particles deposit deeper than larger particles. When inhaled, particles can increase the number and severity of asthma attacks and cause or aggravate bronchitis and other lung diseases. Community health studies also link particle exposure to the premature death of people with heart and lung disease, especially the elderly.

The number of days with unhealthy levels of inhalable particulate matter (over the state 24 hr standard of 50 micrograms per cubic meter ($\mu g/m^3$) describes the chronic extent of PM10 pollution. Despite the increase in population in urban areas and subsequent increase in vehicle miles traveled, PM10 levels are decreasing within most regions of the state.

What factors influence this indicator?

Exceedances of PM10 standards are influenced by emissions of directly-emitted particles and gases that form secondary particles in the atmosphere. These gases include reactive organic gases (ROG), ammonia, oxides of sulfur (SOx), and oxides of nitrogen (NOx). This indicator is also dependent on weather — secondary particles are more easily formed in the atmosphere during colder winter conditions, while fugitive dust levels are more likely to be higher on dry, windy days.

As more particulate monitors were deployed statewide throughout the 1990s, there was a greater potential to record exceedances in previously unmonitored regions. For example, three PM monitors deployed in San Diego in 1993 (including one at the Otay Mesa border region) contributed to that region's increase in days over the standard.

Technical Considerations:

Data Characteristics

Data needed to determine the days with unhealthy levels of PM10 are readily available from existing networks of air quality monitors in California. The data are maintained on the Aerometric Data Analysis and Management (ADAM) System and on the Federal Aerometric Information Retrieval System (FAIRS) data system. These data represent the highest quality assured PM10 data. The data are amenable to further analysis and processing with common spreadsheet and database software.

Particulate matter is only measured every sixth day. The number of days which exceed the standard are extrapolated from this data.

Strengths and Limitations of the Data

Extensive monitoring using accepted scientific instrumentation is performed in regions where PM10 standards are likely to be exceeded. As PM monitors are added or moved, the number and location of measurements change. On its own, the indicator does not provide information on population exposure. The indicator is also very sensitive to meteorological influences (i.e., windy or rainy days). The indicator is simple, with readily available data, and easy to apply.

Reference:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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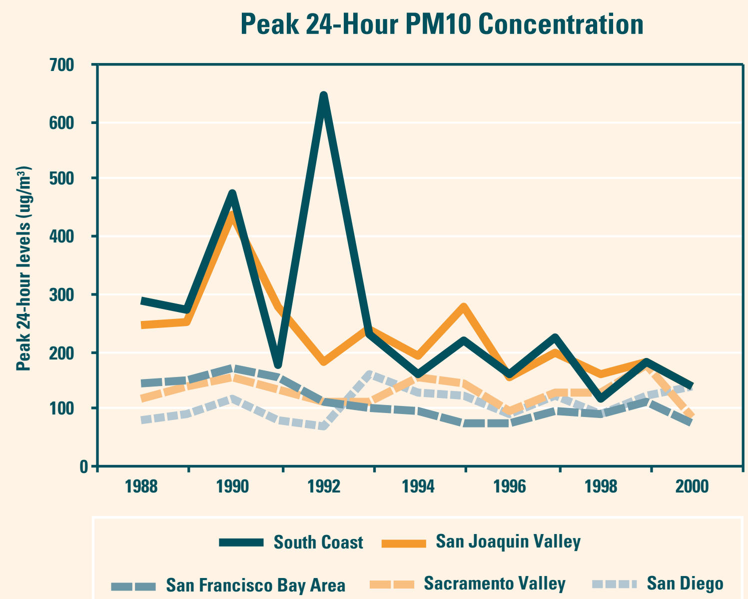
Type I

Level 4
Goal 1

Peak 24-Hour Inhalable Particulate Matter (PM10) Concentration

Exposure to high PM10 levels have declined or remained stable since the mid-1990s.



What is the indicator showing?
Most of the major air basins have shown a moderate decline in maximum 24-hour PM10 concentrations.

Why is the indicator important?

The annual peak 24-hour PM10 concentration represents the "worst-case" for 24-hour exposures to PM10 in a region. When inhaled, particles can increase the number and severity of asthma attacks and cause or aggravate bronchitis and other lung diseases. Community health studies also link particle exposure to the premature death of people with heart and lung disease, especially the elderly.

What factors influence this indicator?

Particulate matter is only measured every sixth day. As more particulate monitors were deployed statewide throughout the 1990s, more measurements in some cases resulted in higher measured peaks. For example, San Diego added a PM monitor at the Otay Mesa border region in 1993. The new Otay Mesa monitor has recorded the San Diego basin's maximum PM10 levels each year since then. PM10 levels are more likely to be higher on dry, windy days, and lower on rainy days. A combination of drought years and high wind events are likely to have contributed to the spikes in PM10 levels in the South Coast and San Joaquin Valley Air Basins in 1990, and in the South Coast Air Basin in 1992.

Technical Considerations:

Data Characteristics

Data needed to determine the annual peak 24-hour PM10 concentration are readily available from existing networks of air quality monitors in California. The data are maintained on the Aerometric Data Analysis and Management (ADAM) System and on the Federal Aerometric Information Retrieval System (FAIRS) data system. These data represent the highest quality assured PM10 data. The data are amenable to further analysis and processing with common spreadsheet and database software. The 2001 Almanac is another useful source of annual average PM10 concentration data.

Strengths and Limitations of the Data:

While the indicator is simple, with readily available data, and easy to apply, it does not describe the number of monitors over the standard on a given day or provide population exposure information. The indicator is also very sensitive to meteorological influences.

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

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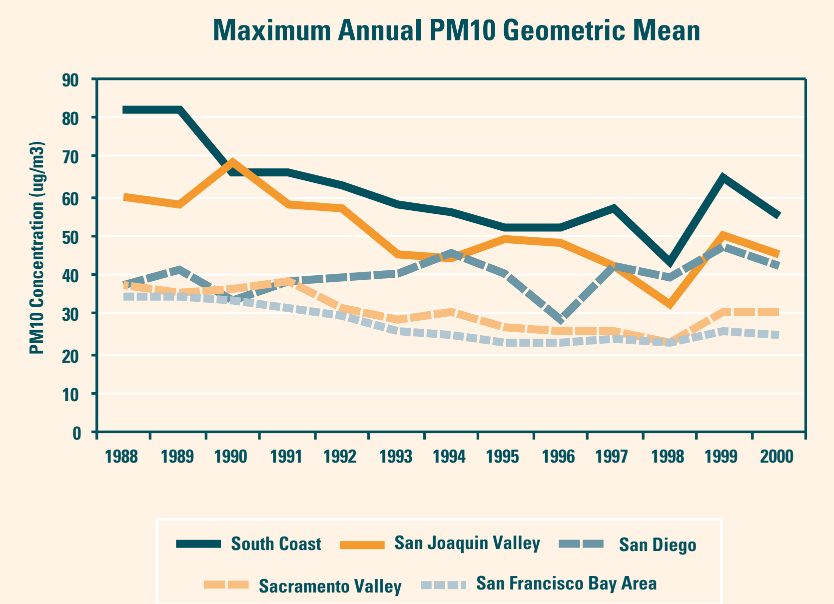
Type I

Level 4
Goal 1

Annual Inhalable Particulate Matter (PM10) Concentration

Long-term exposure to PM10 levels have declined or remained unchanged.



What is the indicator showing?

Most air basins show moderate declines in annual PM10 levels.

Why is this indicator important?

Studies suggest that long-term exposure to inhalable particulate matter can contribute to breathing disorders, reduce lung function, and curtail lung growth in children. The indicator takes into account PM10 levels (collected every sixth day) during all seasons over a year, and provides a measurement for long-term exposure. California's maximum annual geometric mean PM10 standard (similar to maximum average annual PM10 concentration) is 30 micrograms per cubic meter ($\mu g/m^3$); the state standard will be attained when the maximum annual PM10 geometric mean is below this level. Most of the state's major urban areas and the Central Valley exceed the state standard.

What factors influence this indicator?

This indicator represents the highest annual mean PM10 concentration at any monitor within each air basin. In other words, the annual mean PM10 concentration was calculated for each monitoring site in an air basin and the highest mean among all of the sites is utilized.

As more particulate monitors were deployed statewide throughout the 1990s, more measurements in some cases resulted in higher annual mean concentrations. For example, the annual mean PM10 concentration in San Diego has been influenced by the addition of a new PM10 monitor at the Otay Mesa border in 1993.

The indicator by itself presents only limited information on ambient levels of PM10 in the state.

The suite of indicators for PM10 shows that despite the increase in population and vehicle miles traveled, PM10 levels are decreasing within most regions of the state. As California's population continues to grow, however, it will be increasingly difficult to sustain the emission reductions achieved thus far, particularly in the fastest growing parts of the state.

Technical Considerations:

Data Characteristics

The maximum annual PM10 geometric mean is similar to the average annual PM10 concentration, but is calculated by multiplying the highest 24-hour average PM10 concentration recorded every sixth day (particulate matter is only measured every sixth day) for a year, and then taking the nth root of that number. The methodology used to develop the maximum annual geometric mean indicator meets all of the primary criteria, and extensive monitoring using accepted scientific instrumentation is performed in regions where levels of PM10 may be expected to be exceeded. The indicator is a common method of presenting PM10 exceedances in other states and the information gathered is cost-effective.

The maximum annual geometric mean PM10 concentration represents the "worst-case" for annual average exposures to PM10 in a region. This indicator can be used to approximate a region's status with respect to an annual PM10 standard. It can also be used to construct trends for maximum annual average PM10 concentrations that respond to changes in the primary and secondary emissions of PM10.

Data needed to determine the annual average PM10 concentration are readily available from existing networks of air quality monitors in California. The data are maintained on the Aerometric Data Analysis and Management (ADAM) System and on the Federal Aerometric Information Retrieval System (AIRS) data system. These data represent the highest quality assured PM10 data. The data are amenable to further analysis and processing with common spreadsheet and database software. ARB's 2001California Almanac of Emissions and Air Quality is another useful source of data regarding annual average PM10 concentrations.

Strengths and Limitations of the Data

The indicator is simple, with readily available data, and easy to apply.

The limitations of this indicator include: the indicator does not allow computation of the number of monitors that were over the standard on a given exceedance day, does not provide information on population exposure, and is very sensitive to meteorological influences.

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

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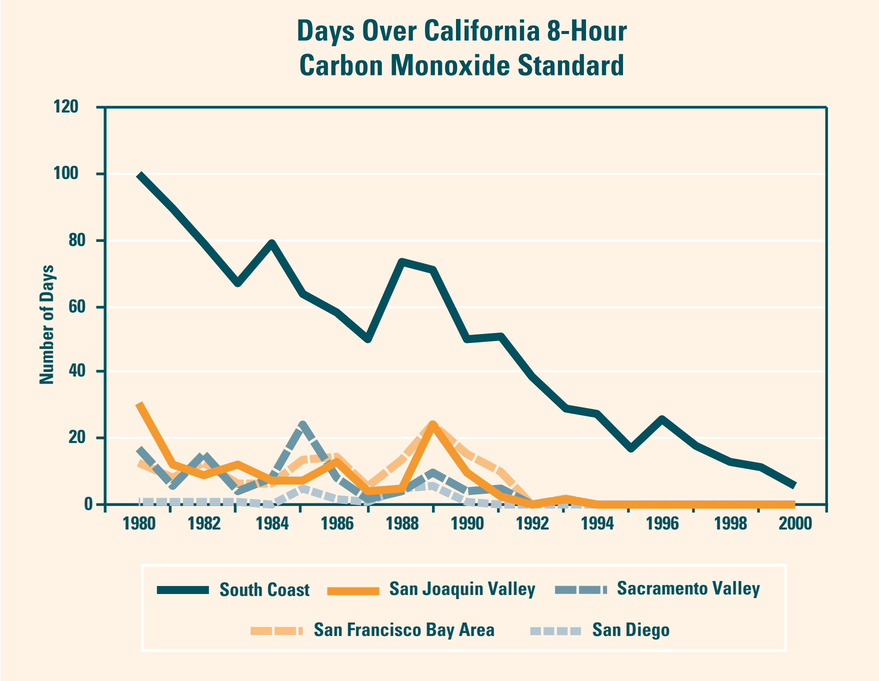
Type I

Level 4
Goal 1

Days with Unhealthy Levels of Carbon Monoxide

Only the Los Angeles area and Calexico still exceed the state 8-hour carbon monoxide standard.



What is the indicator showing?

Days with unhealthy levels of carbon monoxide are decreasing throughout the state. The Los Angeles area was the only major urbanized area with any unhealthy days since the early 1990s.

Why is the indicator important?

Carbon monoxide is harmful because it is readily absorbed through the lungs to the blood, where it binds with hemoglobin and reduces the ability of blood to carry oxygen. As a result, insufficient oxygen reaches the heart, brain, and other tissues. The harm caused by carbon monoxide can be critical for people with heart disease, chronic lung disease, and for pregnant women. Exposure to high levels of carbon monoxide can result in headaches, dizziness, fatigue, slowed reflexes, and death.

Attainment of carbon monoxide standards requires that concentrations rarely exceed a prescribed level. For example, the level of California's 8-hour carbon monoxide standard is 9.0 ppm; when on average only one day per year is above this level (with few exceptions), the state standard will be attained.

The only region in California that is currently in non-attainment of the federal and state 8-hour carbon monoxide standards is the South Coast Air Basin and Calexico. The city of Calexico is in Imperial Valley just north of the Mexican border from Mexicali. It is suspected that the high carbon monoxide levels in Calexico are a cross-border pollution issue (further information on cross-border air quality issues can be found in the Transboundary Indicator section).

This indicator is selected to express the chronic nature of carbon monoxide exceedances in regions where standards are not yet attained. Other carbon monoxide indicators discussed below represent “worst-case” exposure.

What factors influence this indicator?

Carbon monoxide is a colorless and odorless gas that is directly emitted as a product of combustion. Incomplete combustion will result in increased carbon monoxide emissions. Motor vehicles generate over 85 percent of statewide carbon monoxide emissions. The highest concentrations are generally associated with cold, stagnant weather conditions that generally occur in the winter. In contrast to ozone, which tends to be a regional pollutant, carbon monoxide problems tend to be localized. Statewide, the number of days with unhealthy levels of carbon monoxide statewide decreased by 90 percent over the past two decades (from an average of 150 in 1981-83, to 15 in 1997-99).

Technical Considerations:

Data Characteristics

The number of days with unhealthy levels of carbon monoxide represents the chronic nature of 8-hour exposures in a region. This indicator can be used to approximate a region’s status with respect to an 8-hour carbon monoxide standard. It can also be used to construct trends that may respond differently over time compared to other carbon monoxide indicators. As emissions of carbon monoxide decrease, this indicator should respond with reduced counts of days with unhealthy carbon monoxide concentrations.

Data needed to determine the number of days with unhealthy levels of carbon monoxide are readily available from existing networks of air quality monitors in California. The data are maintained on the Aerometric Data Analysis and Management (ADAM) System and on the Federal Aerometric Information Retrieval System (AIRS) data system. These data represent the best quality-assured carbon monoxide data.

Strengths and Limitations of the Data

Although the indicator is simple, with readily available data, and easy to apply, it does not show the number of monitors that were over the standard on a given exceedance day. In addition, this indicator does not provide information on population exposure, and can be sensitive to meteorological influences.

References:

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/adq.htm

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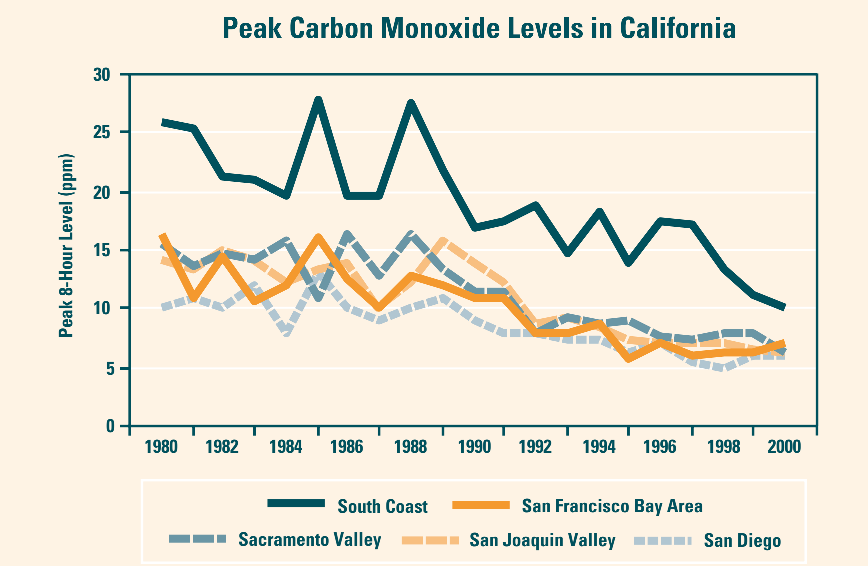
Type I

Level 4
Goal 1

Peak 8-Hour Carbon Monoxide Concentration

Peak carbon monoxide levels have been declining.



What is the indicator showing?

Peak 8-hour carbon monoxide levels have declined and remained below the state 8-hour standard (9.0 ppm) since the mid-1990s in all but the South Coast air basin. However, the South Coast was near attainment in 2000.

Why is this indicator important?

Inhalation of high levels of carbon monoxide reduces the bloods' ability to carry oxygen and can lead to insufficient oxygen reaching the heart, brain, and other tissues. Carbon monoxide inhalation can also impede coordination, worsen cardiovascular conditions, and produce fatigue, headache, weakness, confusion, disorientation, nausea, and dizziness. Very high levels can cause death. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising. Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive.

The peak 8-hour carbon monoxide concentration is related to the status of measured carbon monoxide data with respect to the state standard of 9.0 ppm, and represents the "worst-case" concentration over 8-hours during that year for a particular region.

What factors influence this indicator?

During the 1980s, carbon monoxide was a major air pollutant in California. With the introduction of more stringent automobile emission standards, only a few locations continue to violate the state 8-hour carbon monoxide standard. In the last twenty years, peak 8-hour carbon monoxide levels decreased in the South Coast almost 30 percent, from an average of 24 ppm in 1981-83, to 17 ppm in 1997-99.

Technical Considerations:

Data Characteristics

Data needed to determine the annual peak 8-hour carbon monoxide concentration are readily available from existing networks of air quality monitors in California. The data are maintained on the Aerometric Data Analysis and Management (ADAM) System and on the Federal Aerometric Information Retrieval System (AIRS) data system. These data represent the best quality-assured carbon monoxide data.

The peak 8-hour carbon monoxide concentration is supported by routine, extensive monitoring using accepted scientific instrumentation in regions where carbon monoxide standards may be exceeded. The indicator is a common method of summarizing carbon monoxide data in relation to carbon monoxide standards. Furthermore, this indicator is convenient to calculate and easy to explain to all audiences.

Strengths and Limitations of the Data

The strengths of the indicator include the ability to chart carbon monoxide air quality as it responds to emission reduction programs. The indicator is simple, with readily available data, and easy to apply.

On its own, the indicator does not show the number of monitors that were over the standard on a given exceedance day. In addition, this indicator does not provide information on population exposure, and it tends to be very sensitive to meteorological influences.

References:

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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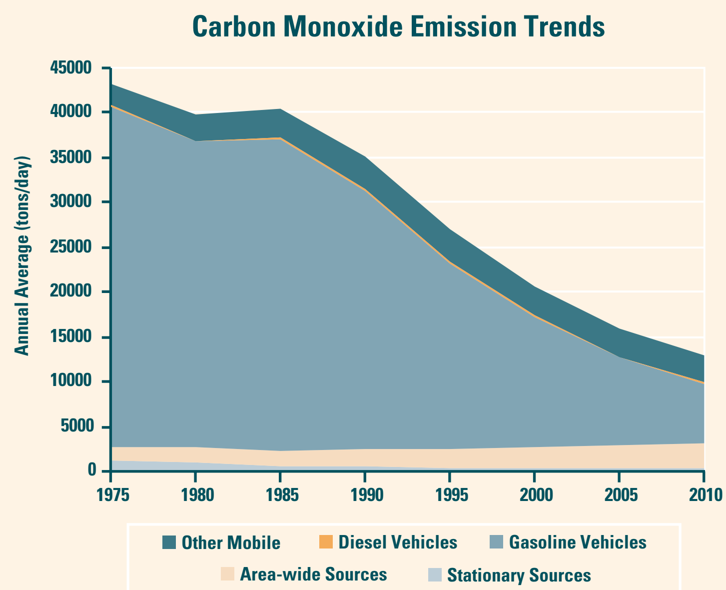
Type I

Level 3
Goal 1

Carbon Monoxide Emissions

Statewide emissions have been declining.



What is the indicator showing?

Total emissions of carbon monoxide have been declining over the last 25 years, primarily due to gasoline vehicle emission reductions.

Why is this indicator important?

Inhalation of high levels of carbon monoxide reduces the bloods' ability to carry oxygen and can lead to insufficient oxygen reaching the heart, brain, and other tissues. Carbon monoxide inhalation can also impede coordination, worsen cardiovascular conditions, and produce fatigue, headache, weakness, confusion, disorientation, nausea, and dizziness. Very high levels can cause death. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising. Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive.

What factors influence this indicator?

Carbon monoxide is a colorless, odorless gas that is directly emitted as a product of combustion. The highest ambient concentrations are generally associated with cold stagnant weather conditions that occur during winter. In contrast to ozone, which tends to be a regional pollutant, carbon monoxide problems tend to be localized. Carbon monoxide emissions can be used in combination with air quality models to estimate regional and microscale impacts of emissions on neighborhoods. Carbon monoxide emissions originate predominantly from mobile sources, especially on-road gasoline vehicles.

Even though motor vehicle miles traveled (VMT) have continued to climb, the adoption of more stringent motor vehicle emissions standards has contributed to a 60 percent decline in statewide carbon monoxide emissions from on-road motor vehicles between 1975 and 2000 (see transportation background indicator for more information on VMT). With continued vehicle fleet turnover to cleaner vehicles and the incorporation of cleaner burning fuels, carbon monoxide emissions are forecasted to continue decreasing through the year 2010. Carbon monoxide emissions from other mobile sources are also projected to decrease through 2010 as more stringent emissions standards are implemented. Emissions from area-wide sources are expected to increase slightly due to increased waste burning and additional residential fuel combustion resulting from population growth.

Technical Considerations:

Data Characteristics

Air pollution control districts report emissions from stationary sources to the Air Resources Board on a yearly basis. Emissions from area-wide and natural sources are estimated using engineering methods on a rotating three-year basis. Carbon monoxide emissions from mobile sources are estimated with computer models yearly.

Emissions estimations are based on diverse sources of data, such as process rates for specific companies, emissions standards and vehicle miles traveled for cars, and number of heating degree days for a given year.

Strengths and Limitations of the Data

Although some air pollution control districts update their data yearly, others have not updated their emissions data for many years. Many area-wide source estimation methodologies are based on old data and are adjusted yearly with the use of surrogates. Because carbon monoxide emissions data are heavily dependent on methodologies and models that may or may not change from year to year, and because emissions are estimated on an annual basis, they are not sensitive to temporal changes of a year or less.

A major strength of this indicator is that it accurately reflect long-term changes in emission trends over a period of multiple years. Major improvements in estimation methodologies, or development of methodologies for previously uninventoried sources, may result in misleading changes in emission levels between years. To lessen this problem, emission trends are not measured – they are backcasted or forecasted based on growth and control data so that the inventory reflects consistent methodologies across the trend years.

References:

California Air Resources Board. The 2001 California Almanac of Emissions and Air Quality. Posted at: www.arb.ca.gov/aqd/almanac01/almanac01.htm

California Air Resources Board. Emission Inventory Procedural Manual, Volumes I-V, 1997.

ARB Emission Inventory Web Page, Posted at: www.arb.ca.gov/emisinv/eib.htm

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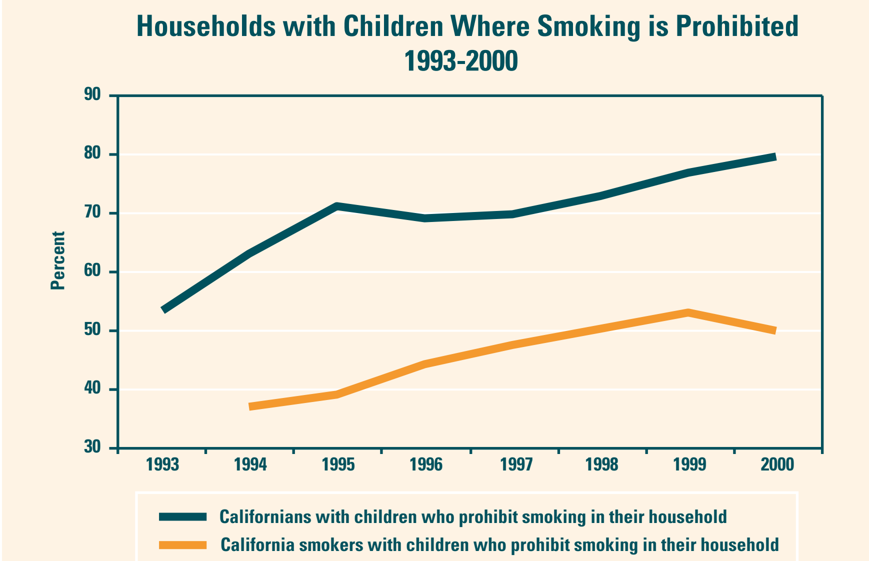
Type I

Level 2
Goal 1, 4

Household Exposure of Children to Environmental Tobacco Smoke (ETS)

There has been a steady increase in the number of households with children under 18 where smoking is prohibited.



What is this indicator showing?

Since 1993, yearly statewide surveys have shown a steady increase in the number of households with children where smoking is prohibited. In households with adult smokers, the percentage of homes with a smoking prohibition is lower than all households, but there is a principally increasing trend towards banning smoking in the home.

Why is this indicator important?

Environmental tobacco smoke (ETS), or second-hand smoke, is a major toxic indoor air contaminant and is of particular danger to the young. For infants and children, the single most important location for ETS exposure is the home. ETS exposure has been associated with lung cancer, childhood asthma and lower respiratory tract infections. Developmental effects associated with ETS exposure include low birth weight, sudden infant death syndrome, and an increased occurrence of childhood asthma (Cal/EPA, 1997). This indicator is based on a survey and provides only qualitative data. Therefore, the indicator is an approximation of infant and child exposure to ETS in the home.

What factors influenced this indicator?

In 1993, about one-half of all Californians with children under 18 prohibited smoking in the household. By 2000, nearly four out of five households with children under 18 had a prohibition on smoking. For households with children and adult smokers, about half prohibited smoking in their home in 2000, compared to about 37 percent in 1994. Due to Proposition 99, various tobacco-related health protection programs have been funded in the last 10 years, some of which specifically address childhood exposure to ETS in the home. These programs have been credited with increasing the recognition of the danger of household ETS exposure. Available data indicate that the prevalence of household ETS exposure in California is about 15 percent lower on average than elsewhere in the U.S., and is related to the lower percentage of adult smokers in California.

Technical Considerations:

Data Characteristics

Approximately 4000 California adults are surveyed annually to assess household smoking habits and rules. The survey is funded and collected by the Tobacco Control Section and the Cancer Surveillance Section, respectively, of the California Department of Health Services.

Strengths and Limitations of the Data

Annual surveys to assess smoking rules within households represent one of the easiest, most cost-efficient ways to quickly gather qualitative ("yes" or "no" type questions) information. While studies on the reliability of questionnaire responses indicate that they are generally trustworthy, use of quantitative data in conjunction with surveys shows that the surveys may underestimate the actual ETS exposure (Cal/EPA, 1997). The surveys are not intended to address questions regarding race/ethnicity, socio-economic status, and other variables.

While quantitative measures of ETS exposures are available, these are more expensive and labor intensive than collection of survey data, and have not been attempted on an ongoing basis. Such quantitative measures include the use of personal monitors and the measurement of ETS substances in saliva, urine and blood. The chemical cotinine, a breakdown product of nicotine, can be measured in bodily fluids and is an indicator of smoking and ETS exposure. However, the need for routine, ongoing biomonitoring of children for cotinine levels may be superfluous, given that the ETS survey is likely a sufficient indicator to reflect the trend in household ETS exposure. In addition, cotinine can be measured up to a day or two after exposure and may represent more of a measure of general exposure rather than household exposure.

References:

California Department of Health Services, California Adult Tobacco Survey (CATS), California Tobacco Control Update, Tobacco Control Section, Sacramento, California, 1993 to 2000.

California Department of Health Services, California Tobacco Control Update, Tobacco Control Section, Sacramento, California, August 2000, Posted at: www.dhs.ca.gov/tobacco

California Environmental Protection Agency. Health Effects of Exposure to Environmental Tobacco Smoke. Executive Summary, Office of Environmental Health Hazard Assessment. September 1997. Posted at: www.oehha.org/air/environmental_tobacco/finalets.html

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Type II

Total primary and precursor PM10 emissions

PM10 refers to particles with an aerodynamic diameter of 10 microns or smaller. Primary particles are emitted directly into the atmosphere while PM10 precursors are gases that are transformed into particles in the atmosphere. In addition to collecting data on PM10 levels, the Air Resources Board has recently begun a program for collecting data on PM2.5 levels statewide. Particles within the PM2.5 fraction of PM10 penetrate more deeply into the lungs, and is likely composed of a greater proportion of precursor gases than PM10. It is expected that data for indicators of PM2.5, similar to those presented for PM10, will be available within a few years. More information on the PM2.5 program can be found at: www.arb.ca.gov/aqd/pm25/pmfdsign.htm (PM2.5 Monitoring Network Design for California).

While methodologies exist for estimating primary PM10 emissions, there is a need for a better understanding of how precursor pollutants — such as reactive organic gases (ROG), ammonia, oxides of sulfur (SOx), and oxides of nitrogen (NOx) — contribute to the formation of inhalable particles. Work being done by the California Air Resources Board and other stakeholders will provide a better understanding of the composition of PM10 and PM2.5 and the relative contribution of precursor emissions to these pollutants. This information will help regulators determine the toxicity of PM10 and PM2.5 and pursue the most effective pollution control strategies. The PM precursor program is a priority for the Air Resources Board and the first data for this indicator is expected within five years.

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

California Air Resources Board. Emission Inventory Procedural Manual, Volumes I-V, 1997.

ARB Emission Inventory Web Page, Posted at: www.arb.ca.gov/emisinv/eib.htm

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Type II

Total emissions of toxic air contaminants (TACs)

TACs are emitted from numerous sources, including: stationary sources, such as electric power plants and refineries; area-wide sources, such as consumer products and architectural coatings; on-road motor vehicles, such as automobiles and trucks; and off-road motor vehicles such as trains, ships, aircraft and farm equipment.

The Air Resources Board periodically publishes inventories of criteria and toxic air pollutants from all categories of emission sources. ARB's most comprehensive TAC inventory — the California Toxics Inventory (CTI) — was last updated in 1996 and contains emissions for 33 toxic air pollutants in California's 58 counties.

The CTI is a snapshot of a variety of dynamic and variable processes. The stationary source data were developed from point sources reporting through the Air Toxic Hot Spots Program. The point source emission data represent the best available information for the source. However, the 1996 CTI emissions data may not have been specifically collected for that year. The ARB developed estimates for area sources and mobile sources using the 1996 criteria pollutant inventory and speciating total organic gas and particulate matter emissions into specific toxic pollutant emissions. The document "Basis for Determining 1996 Toxics Emissions, California Toxics Inventory" contains the procedures used by the ARB to develop the CTI.

The next update of the CTI inventory is expected by the end of 2001, thus allowing the development of a trend for TAC emissions in the state.

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

California Air Resources Board, Air Toxics Hot Spots (AB†2588) Program Web Site. Posted at: www.arb.ca.gov/ab2588/ab2588.htm

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Community-based cancer risk from exposure to toxic air contaminants (TACs)

Type II

Eighty-eight percent of the cancer risk from TACs that have been quantified derives from three pollutants – diesel particulate matter (70 percent), benzene (10 percent), and 1,3-butadiene (8 percent). These three TACs derive primarily from mobile sources. Mobile, stationary, and area-wide TAC emissions can combine to pose potential cancer and noncancer health risks, particularly in urbanized areas.

This indicator will utilize data collected from air monitors and dispersion modeling to estimate ambient concentrations of air toxics throughout California. These estimated concentrations will be used to calculate excess cancer risk for each toxic air contaminant, and a cumulative risk will be calculated by adding estimated risk values for the toxic air contaminants in an air basin and/or a community. The results will be overlaid by demographic data using a GIS-based program. Additional demographic data, such as average income or ethnic background can also be utilized to address environmental justice issues. The GIS capability and tracking for assessing environmental justice-related issues are under development.

The ARB has monitored the TACs of greatest concern since 1990 at about 20 air monitoring sites located primarily in urban areas of the state. Ten years of TAC air concentrations are posted at the ARB website (www.arb.ca.gov/aqd/aqd.htm), along with the estimated cancer risk. The latter is expressed as the number of potential excess cancer cases per million people exposed over a lifetime (70-year) to the annual average concentration. Over the past 10 years, about a 50 percent decrease in the estimated cancer risk is seen at almost every monitoring site. However, the cancer risk values should not be regarded as absolute predictors of the actual risks faced by Californians, but rather as useful in representing the relative risk among the various TACs and to provide a general indication of trends.

Again, caution should be used in interpreting the cancer risk values literally as expected excess cancer cases per million people. Given that cancer risk assessments are intended to guide the development of regulatory standards to protect against the adverse effects of a chemical, a number of health-protective assumptions are used in the process of calculating the cancer risk values. For example, the vast majority of Californians are exposed only to minute amounts of these TACs (typically in the parts per billion range). The health-protective assumption is made that there is some risk to any exposure, no matter how small. In addition, it is known that there is variability and uncertainty among the human population with regard to the potential to develop cancer during a lifetime exposure to a cancer-causing TAC.

Thus, a scientifically accepted statistical method is applied to the data on a TAC's cancer potency to determine the 95 percent upper confidence limit of the slope of the dose-response curve. This allows for the uncertainties in our ability to predict the sensitivity of an individual to a cancer-causing chemical, and we believe that a level calculated in this way would protect the great majority of the human population adequately. Although it is theoretically possible that a given cancer risk prediction for a TAC is either an over- or under-estimate, the calculation is designed to produce a result which is probably an over-estimate, in order to be sure of protecting public health.

With this in mind, the TAC monitoring data and associated health risks for California air basins and counties can be viewed at: www.arb.ca.gov/aqd/almanac01/chap601.htm

References:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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Type II

Cumulative exposure to toxic air contaminants (TACs) that may pose chronic and acute health risks

TACs can be emitted by stationary sources, area-wide sources, and mobile sources. Some of the most prevalent TACs include diesel particulate matter, benzene, and formaldehyde. TACs present both potential cancer and noncancer health risks, particularly in heavily urbanized regions.

Noncancer (chronic and acute) health endpoints are assumed to have a threshold for effect. If the exposure is below the individual's threshold for effect, then no adverse effect would be expected. However, simultaneous exposure to two similar chemicals at sub-threshold levels may result in a toxic response. The combined impact of several chemicals present at the same time are assessed assuming the interaction of the chemicals will be additive for a given toxicological endpoint (such as eye or throat irritation), unless information is available to the contrary.

This indicator would utilize air monitoring data and dispersion modeling to estimate ambient concentrations of air toxics throughout California. Particular attention will be paid to the main air basins known to have the highest air levels of TACs in California (South Coast, San Diego, San Joaquin Valley, San Francisco Bay Area, and Sacramento Valley). Currently, the data on long-term ambient air concentrations of TACs are being compiled and will be presented in a future indicator for chronic noncancer risk. Collection of acute TAC exposure data is more resource intensive since it requires hourly ambient concentration data. The acute noncancer risks posed by TACs may be presented in a future indicator, as more complete data on hourly levels of TACs is collected.

Reference:

California Air Resources Board. ADAM Air Quality Database. Posted at: www.arb.ca.gov/aqd/aqd.htm

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Visibility on an average summer and winter day and in California national parks and wilderness areas

Type II

One of the most intuitive methods used by the public to assess air quality is to visually assess the distance one can see. More exact measures of visibility and visibility trends, however, are more difficult to come by. Visibility records, developed using a variety of measurements, are available for a small number of sites in California. However there is no statewide database from which to assess visibility trends, and development of such data is extremely resource intensive. Visibility can also be measured indirectly by "reconstructing" visibility based on the light extinction characteristics of the particles in air. "Speciated" particulate monitors provide data about the chemical composition of ambient particles that can be used to reconstruct visibility. A monitoring network that speciates fine particulates in California is gearing up and is expected to provide detailed data within the next few years.

Since particulate matter (PM) composition and spatial distribution vary seasonally, visibility should be reported separately for summer and winter. For trend tracking purposes, reporting visibility as average summer and average winter visual ranges will provide a measure of progress on improving visibility in California.

In 1999, the U.S. EPA promulgated a regional haze regulation that calls for states to establish goals and emission reduction strategies for improving visibility in 156 Class 1 Areas (national parks and wilderness areas), 29 of which are in California (including Yosemite, Redwood, and Joshua Tree National Parks). Currently, there are 17 monitors deployed in California's Class I areas to specifically evaluate visibility trends. As reconstructed visibility data from those sites becomes available, we will incorporate this data into our assessment.

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Type III

Indoor exposure to formaldehyde

Studies of human exposure to air pollutants indicate that indoor levels of many air pollutants may be two to five times (and occasionally more than 100 times) higher than outdoor levels. This is of special concern since people spend, on average, 90 percent of their time indoors.

Formaldehyde is a pollutant of concern for indoor air. Formaldehyde levels have been found at concentrations that are many times higher than outdoor concentrations. Formaldehyde exposure can cause eye, nose, and throat irritation, wheezing and coughing, fatigue, skin rash, and cancer. Indoor sources of formaldehyde include pressed wood products (for example, hardwood plywood, particleboard, and medium density fiberboard), furniture made with these pressed wood products, combustion (e.g., wood burning and cigarette smoke), durable press drapes, other textiles, glues, cosmetics, and many other products. Formaldehyde exposures in homes and other indoor environments can be reduced by a variety of source control measures such as using improved or substituted products that contain little or no formaldehyde, source removal or avoidance, source barriers, and climate control.

Monitoring data for formaldehyde (or any other pollutant) within homes, schools or public buildings are scarce. The ubiquitous nature of formaldehyde sources, their proximity to people, and the reduced ventilation in some indoor environments, however, suggest that the potential for unhealthy exposures is high. An indoor air indicator for this pollutant would help determine the extent of the problem and the effectiveness of any actions taken to reduce levels of this hazardous gas in indoor air.

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Water

Introduction

Water is one of California's most precious resources, serving a multitude of needs, including drinking, recreation, supporting aquatic life and habitat, and agricultural and industrial uses. It provides an essential lifeline for the state's burgeoning population of approximately 35 million. The management, assessment, and protection of California's water for all beneficial uses are of paramount concern for all of California's inhabitants.

To meet this challenge, California's water resources are addressed by an array of different agencies. Each agency approaches water resources from a unique perspective, based on its individual mandate. In a cooperative effort, the various agencies work toward managing and protecting California's surface water and groundwater resources for its many uses for the benefit of present and future generations. Such uses include drinking and other household uses, crop irrigation, industrial and recreational uses, and fish and wildlife habitat. The water indicators presented in this section are organized based on the many beneficial uses of California's water resources. In addition, indicators are also included that pertain to the specific threats to water resources, such as leaking underground fuel tanks (LUFTs). As water is closely related to many environmental issues, additional environmental indicators related to water resources may be found in other sections of this chapter (Ecosystem Health, Pesticides, Transboundary Issues, and Land, Waste and Materials Management).

Drinking Water Quality

Drinking water is highly regulated. Federal and state laws require that municipal drinking water sources be monitored regularly for a number of chemical, radiological and bacteriological contaminants and conform to standards, called maximum contaminant levels (MCLs), that provide for protection of public health. From time to time, these standards may be revised as needed, such as to reflect

Water Indicators

Water quality

Multiple beneficial uses

Aquatic life and swimming uses assessed in 2000 (Type I)

Spill/Release episodes – Waters (Type I)

Leaking underground fuel tank (LUFT) sites[1] (Type I)

Groundwater contaminant plumes – Extent[1] (Type II)

Contaminant release sites[1] (Type II)

Drinking water

Drinking water supplies exceeding maximum contaminant levels (MCLs) (Index)

Recreation

Coastal beach availability – Extent of coastal beaches posted or closed (Type I)

Fish and shellfish

Bacterial concentrations in commercial shellfish growing waters (Type I)

Fish consumption advisories – Coastal waters (Type I)

Fish consumption advisories – Inland waters (Type III)

Water supply and use

Statewide water use and per capita consumption (Type I)

Water use efficiency – Recycling municipal wastewater (Type I)

Groundwater supply reliability (Type III)

[1] Primary beneficial use affected is drinking water but others may apply.

changes in the state of knowledge regarding the health effects of contaminants. Also, the addition of new substances to the list of regulated contaminants occurs when necessary.

Overall, conformity with drinking water standards is very good and the quality of statewide municipal drinking water is high. The monitoring of public drinking water systems provides information that can be used as environmental indicators for specific chemicals and chemical types.

Surface Water Quality

Rivers, lakes, estuaries, and marine waters that are fishable, swimmable, and that support healthy ecosystems and other beneficial uses are vital to California. Environmental indicators for surface waters have been drawn from water quality assessments. The state periodically publishes a water quality assessment that lists surface waters and their conditions. These assessments provide the basis for listing of surface waters under federal requirements, such as Clean Water Act sections 303(d) and 305(b), and provide context and characterization of the extent of surface water quality conditions in the state.

While actual water quality conditions may remain static in a water body, its assessed condition may change due to new standards. Advances in the understanding of the impacts of pollutants on human health and the environment, as well as improvements in assessment technology and monitoring, may result in changes in the standards of assessment. Thus, assessments may not always be conducted in a consistent fashion over time. Accordingly, care should be exercised in drawing conclusions from surface water quality indicators presented in this section.

The indicators here reflect the safety of human consumption of aquatic life, and thus are closely linked to the quality of surface water. Excessive levels of chemical contaminants in surface water bodies may accumulate in fish to levels that make them unsafe to eat. Historical studies and ongoing monitoring have been used to perform risk assessments and issue appropriate fish consumption advisories. Fish consumption advisories describe what quantity of fish from a specified area a person can safely consume over a specified period of time without posing a significant threat to their health.

Impairments of beneficial uses often occur over long periods of time and can require years to correct. To provide shorter-term indicators of trends in water quality, episodes related to spills and beach closures and postings are included. Even in the case where a beneficial use remains impaired from year to year, trends in water quality will be apparent in the number of annual pollution episodes provided by these indicators.

Groundwater Quality

Groundwater basins supply nearly 40 percent of the water Californians use. The assessment of groundwater resources is particularly challenging due to the fact that the nature of subsurface hydrogeology is highly variable. Thus, a comprehensive statewide environmental indicator for groundwater is not currently available. Currently, environmental indicators for groundwater are based on data available for points of groundwater extraction and specific threats to groundwater resources. Threats to groundwater result from a variety of sources including leaking landfills, leaking underground fuel tanks, and other unauthorized releases of contaminants to groundwater. Additionally, in the state's agricultural industry, fertilizers and pesticide use have created elevated nitrate and pesticide levels in groundwater. Left unchecked, these contaminant releases can grow to be extensive groundwater plumes that affect the beneficial uses of groundwater, including drinking water supplies. Furthermore, once groundwater quality has been degraded, it is often very difficult and costly to clean up. Consequently, many drinking water wells have been shut down due to unacceptable concentrations of contaminants.

Although associated primarily with urban areas, municipal drinking water wells exist throughout the state and are subject to continuous monitoring. Similarly, contaminant release sites are under close supervision and monitoring. While these groundwater-related indicators do not provide a full accounting of the general status and trends of the state's groundwater resources, they are currently the best sources of data.

Water Supply

With California's ever-growing population, it is vitally important that we ensure the efficient use of our natural resources, including our water supply. In addition, California is subject to a wide range of hydrologic conditions and, therefore, experiences annual variability in its water supplies. Thus, knowledge of water supplies and water use under a range of hydrologic conditions is necessary to evaluate the needs that water managers must meet. Furthermore, uses and changes in demands for the state's water resources affect the quantity and quality of water available for all beneficial uses. Accordingly, this section presents environmental indicators relevant to water supply, to complement those that focus on water quality.

Issue 1: Water Quality (by beneficial uses)

Sub-issue 1.1: Multiple uses

California's water resources provide many different benefits to the people of the state. These beneficial uses include domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; preservation and enhancement of fish, wildlife, and other aquatic resources or preserves; and many others. Several of these beneficial uses, such as municipal drinking water, are discussed in detail in other sub-issues. Those beneficial uses not separately highlighted in other sub-issues are discussed below.

Also included in this section are the various threats to the beneficial uses of water resources. Pollutants can impact water resources from a variety of sources and via numerous pathways. These sources of pollution affect the beneficial uses of both surface water and groundwater and may include sewerage system overflows, pipeline spills, and other unauthorized discharges such as leaking underground fuel tanks and leaking landfills. Pollution may also result from historical waste management practices and agricultural activities. The number and size of such situations, and the progress of clean up efforts, indicate the amount of water resources damaged. In many cases, these sources of pollution may impact or threaten to impact drinking water supplies. The proximity of such incidents to drinking water sources indicates the potential threat to drinking water, both in terms of reduced water availability and/or additional water treatment costs.

Indicators

Aquatic life and swimming uses assessed in 2000 (Type I)

Spill/Release episodes - Waters (Type I)

Leaking underground fuel tank (LUFT) sites (Type I)

Groundwater contaminant plumes - Extent (Type II)

Contaminant release sites (Type II)

Beneficial uses

Aquatic life and habitat protection

California has over 10,000 lakes, reservoirs and ponds, over 64,000 miles of perennial rivers and streams, and over 1,600 miles of shoreline, all of which support an exceptionally rich flora and fauna. The biological diversity of these inland and marine water bodies plays an important role in the function of the various biological communities and ecosystems. Changes in aquatic environments, including water quality degradation and other environmental stresses such as competition from nonnative species, can have negative consequences on biological diversity and the maintenance of endemic populations.

In addition, the maintenance of physical habitats in aquatic environments is fundamental to the goal of preservation of aquatic communities and populations. Maintenance of particular flow regimes, substrate types, temperature regimes, types of canopy cover, and other physical habitat parameters have substantial effects on the biological resources in and around inland and marine ecosystems. Water quantity issues often arise as competing interests seek to secure water supplies for specific uses, which may lead to stresses being applied to various biological or ecological assemblages. Furthermore, aquatic habitats may also be adversely affected by the degradation of water quality (e.g., temperature increases, decreases in dissolved oxygen concentrations, nutrient and organic loads, and concentrations of various chemicals and suspended solids) resulting from human activities.

Agricultural and industrial water quality

Water resources are vital to agricultural uses, including farming, horticulture, and ranching. The accumulation of salts and trace elements in all waters used for agricultural purposes can have a profound influence on productivity.

Uses of water for industrial activities include cooling water supply, hydraulic conveyance, fire protection, and consumptive uses in making products and cleaning of parts and goods. Water quality requirements differ widely for the many industrial processes in use today. In large part, protection of industrial and agricultural uses of water occurs with protection of more vulnerable uses, such as drinking water and aquatic life.

Aesthetic conditions

Aesthetic acceptability of marine and inland surface waters varies widely depending on the nature of the supply source to which people have become accustomed. However, the parameters of general concern are excessive hardness, unpleasant odor or taste, turbidity, and color. In addition, excessive weed and algae growth, and litter and trash accumulation are significant concerns.

Sub-issue 1.2: Drinking water

One of the most significant beneficial uses of water is for drinking water supplies. Drinking water, whether from groundwater or surface water sources, represents a potential pathway for human exposure to pollution. In practice, because public water systems are constrained by regulation from serving water that exceeds standards (maximum contaminant levels, MCLs), the actual exposure to polluted drinking water may be reduced or eliminated altogether by treating the water prior to service or by taking the source out of service. The indicators developed for this section pertain to MCL exceedances in drinking water sources at the point of entering the drinking water supplies. While the regulation of public drinking water systems is intended to protect the drinking water of most consumers, some consumers rely on smaller unregulated water supply systems.

Contaminants that have been found in drinking water sources include those listed below:

Inorganic:

This general category contains primarily minerals that are naturally occurring, although some, such as arsenic and chromium, may also have industrial or commercial application. It also includes additional substances, such as nitrates, cyanide and perchlorate.

Organics:

This general category contains primarily chemicals that are synthetic and used in industry or commercially. A number of chemicals in this category are byproducts of water treatment (i.e., chlorination). This category does not include pesticides.

Pesticides:

This general category contains primarily pesticides that are or have been used in agriculture.

Radioactivity:

This general category contains primarily radioactivity that is naturally occurring, although strontium-90 is a fission product and a component of historic global fallout from above ground nuclear weapons tests. The category includes general measurements of radioactivity such as gross alpha particles and gross beta particles, and it also includes specific standards for uranium, two radium isotopes, and others.

Indicator

Drinking water supplies exceeding maximum contaminant levels
(Index, Type I)

Indicator

Coastal beach availability – Extent of coastal beaches posted or closed (Type I)

Sub-issue 1.3: Recreation

Beaches are one of California's most valued natural assets. California has over 1,600 miles of shoreline, with the majority of swimming beaches located in southern California. In addition, California has over 10,000 lakes, reservoirs, and ponds and over 64,000 miles of perennial rivers and streams. Many of these freshwater bodies are used seasonally for swimming. Beaches, or more precisely the waters adjacent to the beach, must be safe for swimming and other recreational uses to protect public health. Clean beaches are also important to the local economy that depends on tourism and local visitation and the quality of life for Californians who value being able to visit and swim at the beach. Due to events such as sewerage system spills and polluted urban runoff, certain bacteria may be present in beach waters at concentrations that may pose a threat to public health. In these cases, local health officers close or post beaches to protect public health. Recent laws require more uniform and consistent monitoring and posting/closure decisions by counties to reduce health risks and increase the public's access to beaches.

Indicators

Bacterial concentration in commercial shellfish growing waters (Type I)

Fish consumption advisories – Coastal waters (Type I)

Fish consumption advisories – Inland waters (Type III)

Sub-issue 1.4: Fish and Shellfish Consumption

Uses of water for commercial or recreational collection of fish, shellfish, or other organisms in oceans, bays, and estuaries, including uses involving organisms intended for human consumption or bait purposes, are important to California. To protect this beneficial use, the aquatic habitats where these organisms reproduce and seek their food must be protected. Decreased surface water quality can result in potential human exposures to toxic substances through consumption of contaminated fish and shellfish.

Health advisories are issued when the levels of toxic chemicals in sport fish tissue are deemed to present a potential threat to human health. Similarly, elevated bacterial concentrations in shellfish growing waters can result in potential human exposures to pathogens through consumption of contaminated shellfish.

Issue 2: Water Supply and Use

Managing water supplies to ensure that demands from the various uses are met is a major challenge for California. The Department of Water Resources has addressed water supply and use since 1957, with the issuance of Bulletin 3, the California Water Plan. The California Water Plan is updated by the Bulletin 160 series (published six times between 1966 and 1998) which assesses California's agricultural, environmental, and urban water needs and evaluates water supplies to meet demand. The Bulletin 160 series presents a statewide overview of current water management activities and provides managers with a framework for water resources decisions.

During drought years, groundwater supplies are used to a greater degree than in non-drought years. To meet the water demands during drought years requires an understanding of available groundwater supplies.

One method of increasing water use efficiency is to recycle water for various uses. Municipal wastewater, collected and treated, can be directly used for a variety of beneficial uses, depending on the quality of the effluent. These uses include agricultural and landscape irrigation, industrial cooling water, recreation, and wildlife habitat.

Indicators

Statewide water use and per capita consumption (Type I)

Water use efficiency – Recycling municipal wastewater (Type I)

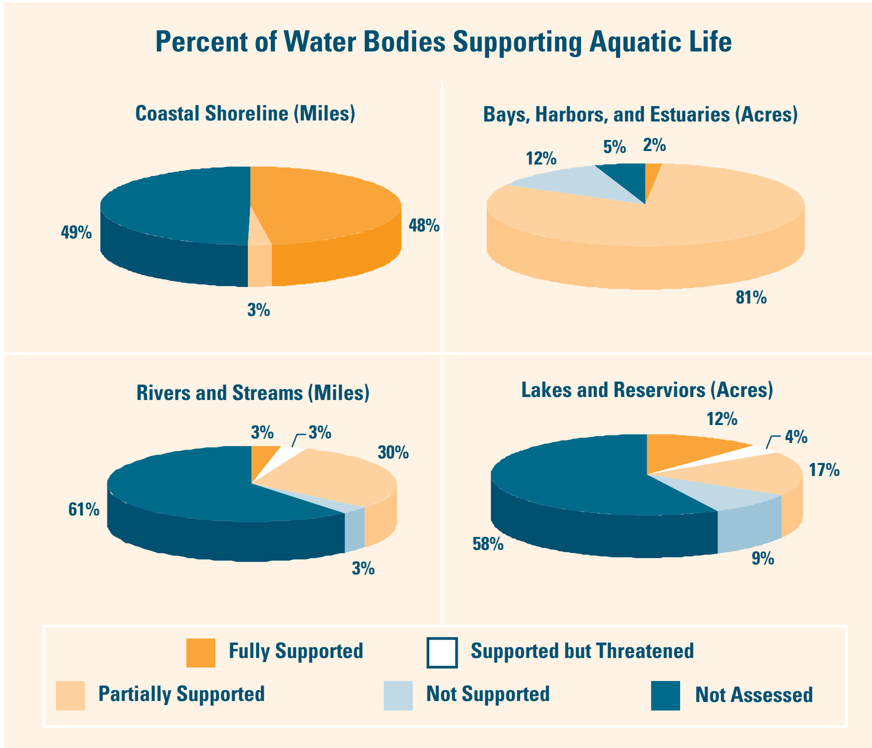
Groundwater supply reliability (Type III)

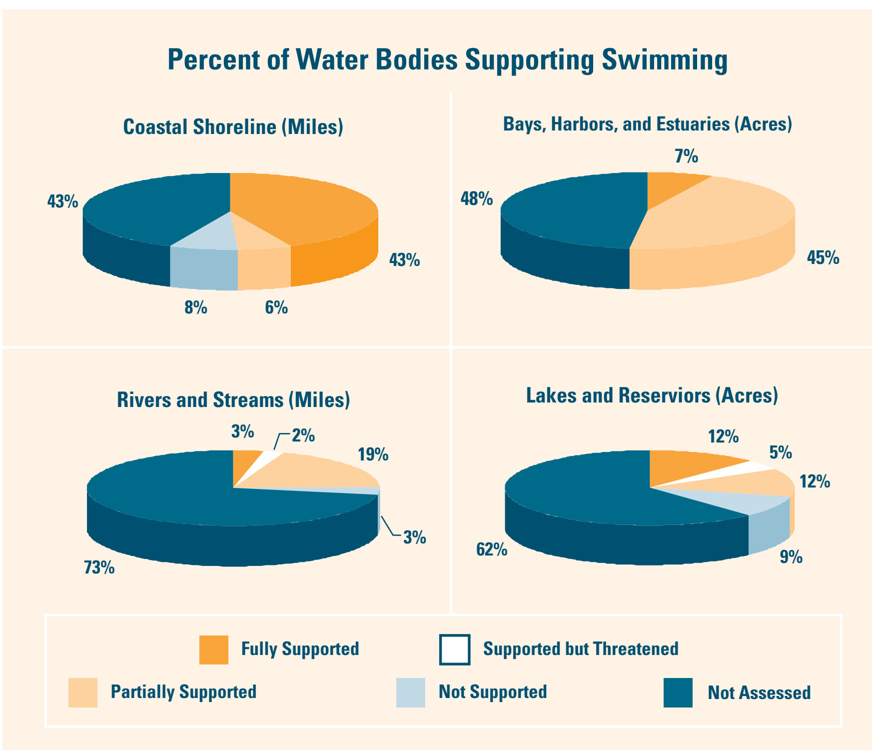
Type I

Level 4
Goal 2

Aquatic Life and Swimming Uses Assessed in 2000

Limited water quality information is available to assess status.





What is the indicator showing?

These figures show the percentage of California's water bodies where two major beneficial uses (aquatic life and swimming) are supported, threatened, partially supported, and not supported for the year 2000. The quality of the data used and the lack of a comprehensive effort to assess these waters limit the interpretation of this assessment. A large percentage of the state's waters have not been assessed.

Why is this indicator important?

The spatial extent of surface water beneficial use support represents an integrated view of the quality of surface water resources. Every two years, the State Water Resources Control Board (SWRCB) develops a Water Quality Assessment (WQA) report pursuant to the federal Clean Water Act that provides an assessment of the status of the waters of the state [see State Water Control Board, *2000 California 305(b) Report on Water Quality*]. The report presents estimates of the area of water bodies and the linear miles of rivers and streams that either support or do not support beneficial uses.

Water quality programs are designed and implemented to concurrently protect all beneficial uses of water including aquatic life, habitat, aesthetic condition, consumption of aquatic organisms, drinking water, and recreation. For the year 2000, this indicator provides the status of aquatic life protection and swimming.

The indicator is presented as the percentage of the state's water body types (e.g., ocean, rivers and streams, lakes and reservoirs, estuaries, enclosed bays, and harbors) that are fully supported, supported but threatened, partially supported, not supported, or of unknown status (the area or linear miles yet to be monitored and assessed). At present, the data needed to perform a comprehensive assessment of all state waters are not available.

What factors influence this indicator?

The major influences on this indicator are the inconsistent approaches used in developing the WQA and the very limited monitoring data for some water body types used in previous assessments. The SWRCB and Regional Water Quality Control Boards (RWQCBs) have not used consistent guidelines in establishing the status of water bodies. At present the information in the WQA cannot be used to make year-to-year comparisons.

The state is addressing this deficiency by the implementation of a new comprehensive Surface Water Ambient Monitoring Program (SWAMP). SWAMP is focused on providing the information to assess all waters of the state and to provide the SWRCB and RWQCBs with the information needed to protect the state's water quality effectively. This new program is designed to provide information on all waters of the state without bias to known impairment. The monitoring program will use consistent sampling and analysis methods. SWAMP will also be: adaptable to changing circumstances, built on cooperative efforts, established to meet clear monitoring objectives, inclusive of already available information, and implemented using scientifically sound monitoring design with meaningful measurements of water quality.

Technical Considerations:

Data Characteristics

The SWRCB reports every two years on the status of individual beneficial use support for a variety of water body types including bays and harbors, coastal shoreline, estuaries, groundwater, lakes and reservoirs, rivers and streams, saline lakes, and freshwater/tidal wetlands. The RWQCBs estimate the size (in acres or miles) of the water bodies that are: (1) fully supporting beneficial uses, (2) supporting but threatened, (3) partially supporting, (4) not supporting, (5) not attainable, and (6) not assessed. For the purposes of the EPIC analysis, percentages were developed based on total miles in the case of perennial streams, perennial rivers, and coastline; and total acres in the case of harbors, bays, estuaries, lakes, and reservoirs.

In developing the state's WQA, the SWRCB and RWQCB use the U.S. Environmental Protection Agency guidance describing the beneficial use support categories. These categories are described below:

1. "Fully Supporting" refers to water of good quality. "Good" waters support and enhance the designated beneficial use.

2. "Fully Supporting But Threatened" refers to those waters of good quality where the beneficial use shows a declining trend in water quality over time.

3. "Partially Supporting" refers to all intermediate and less severely impaired waters. "Intermediate" waters support the beneficial use with an occasional degradation of water quality. The term "intermediate" usually indicates suspected impacts to the beneficial use, i.e., a problem is indicated but inadequate data are available. ""Impaired" water bodies cannot reasonably be expected to attain or maintain applicable water quality standards, and the beneficial use shows some degree of impairment.

4. "Not Supporting" refers to those water bodies in which the beneficial use is severely impaired and which staff judges to merit serious attention.

A variety of data types are used in making the assessments. A sample of the data types used to develop the WQA Report is presented below:

1. *Aquatic life:* biological assemblages, habitat assessment, toxicity testing, and physical/chemical measurements.

2. *Swimming:* bathing area closures or posting data, bacteriological indicator densities, enteric virus densities, etc.

Strengths and Limitations of the Data

Strengths: The SWRCB and RWQCBs have reported water quality conditions in the Water Quality Assessment (WQA) reports for 25 years. These reports provide a general estimate of the degree and scope to which beneficial uses of state waters have been supported or not supported.

Limitations: RWQCB staff uses a significant amount of professional judgement in preparing the WQA. Over the years the criteria used to evaluate data have varied and, consequently, year-to-year comparisons are difficult to make at present. The indicator is probably more influenced by changes in the approach for completing the assessment and the availability of monitoring data than actual improvement or degradation of water quality.

The figures presented above should be interpreted with caution because the analysis reflects a non-statistical assessment of the state's waters using data collected at mostly problem sites.

With this limited and biased information, it is not possible to tell if water quality statewide has improved or degraded until we have (1) improved our data collection and analysis approaches and (2) assessed a greater percentage of the state's waters. Also, since most of the information used in the WQA is collected in response to suspected problems, clean waters are less likely than waters with suspected problems to be targeted for monitoring. Little if any of these data were collected using a probability-based sampling design and, therefore, the WQA areal assessments do not have a statistical basis.

References:

State Water Resources Control Board. *2000 California 305(b) Report on Water Quality.*

State Water Resources Control Board. *Proposal for comprehensive surface water quality monitoring program.* November 2000. Posted at: www.swrcb.ca.gov/ab982/html/swamp.html

For more information, contact:

State Water Resources Control Board
Division of Water Quality
P.O. Box 944212
Sacramento, California 94244
(916) 341-5455

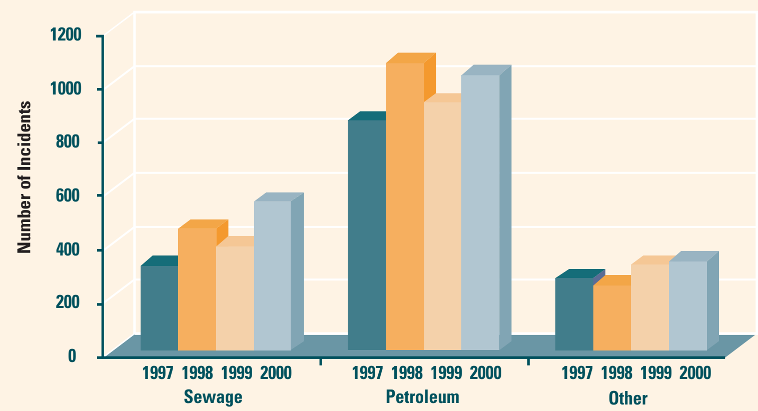
Type I

Level 3
Goal 2, 4

Spill/Release Episodes - Waters

There are more instances of sewage, petroleum and other materials/wastes spilled to waters.

Reports of Spills to Waters Received by the Office of Emergency Services



What is the indicator showing?

From 1997 to 2000, spills to waters reported to the Office of Emergency Services have increased approximately 33 percent. The number of sewage spills increased 76 percent. In general, these spills have caused temporary conditions of pollution or nuisance.

Why is this indicator important?

Spills of wastes and materials affect public health and the environment. This Spill/Release Episodes to Waters indicator tracks the number of reports of spills to waters received by the Governor's Office of Emergency Services (OES) each year.

This indicator shows the number of times each year that uses of waters are threatened or polluted by spills and releases. It also indirectly indicates the level of pollution prevention practices attendant with the handling of municipal sewage, petroleum products and other materials/wastes.

What factors influence this indicator?

OES receives reports of spills from regulated dischargers and the public. In turn, OES advises the Regional Water Quality Control Boards of such instances. Regional Water Quality Control Boards respond to reports of spill incidents that pose a threat to waters of the state. Such spills usually have a short-term effect, causing temporary conditions of pollution and/or nuisance. Typically, temporary conditions of pollution/nuisance are not reflected in the state's periodic assessment of water quality conditions. However, some short-term effects such as a temporary closure of a beach, a temporary shutdown of a drinking water intake, or a fish kill, are accounted for in the coastal beach mile-days indicator and fish advisory indicator. Long-term effects can occur when large quantities or extremely hazardous materials are spilled. When long-term effects are apparent, the water body is a candidate for listing as an impaired water body (see Aquatic Life and Swimming Uses Assessed in 2000 Indicator). In some cases, effects of spills may not be observable or measurable.

Not all reports of spills to OES accurately portray the actual threat to waters; spill volumes and the vicinity of surface and groundwaters are often estimates. Thus, reports may overstate the threat of some situations and understate others. However, OES data provide a good measure to observe annual trends in spill-related episodes.

Technical Considerations:

Data Characteristics

Data have been summarized from OES databases for sewage, petroleum spills to waterways and spills to all waters.

Strengths and Limitations of the Data

The reports include all calls made to the OES Warning Center. The calls are not verified in this database and may include calls which do not affect waters. In addition, all reports to OES are included, regardless of the extent of the threat to public health or the environment.

Reference:

Governor's Office of Emergency Services, Hazardous Materials Spill Database.

For more information, contact:

State Water Resources Control Board
Division of Water Quality
P.O. Box 944212
Sacramento, California 94244
(916) 341-5455

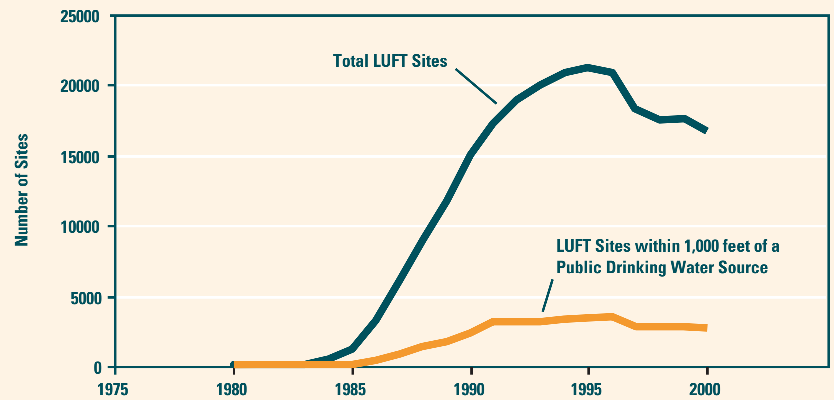
Type I

Level 3
Goal 3

Leaking Underground Fuel Tank (LUFT) Sites

Statewide numbers of LUFT sites are declining.

Leaking Underground Fuel Tank Sites In California



What is the indicator showing?

Trends are shown for the total number of leaking underground fuel tank (LUFT) sites and those LUFT sites within 1,000 feet of public drinking water sources over a 21-year period. Between 1985 and 1995, the number of LUFT sites increased significantly, likely due to increased monitoring. This trend peaked in 1995 and is now steadily decreasing.

Why is this indicator important?

Leaking underground fuel tanks (LUFTs) can act as 'point sources' for shallow groundwater contamination. Depending on the amount of fuel released, the chemical characteristics of the fuel released, the hydrogeologic properties of the aquifer impacted by the release, and the locations of public drinking water sources in relation to the LUFT sites, public water supplies can be threatened or directly impacted. For water quality management purposes, a greater number of fuel releases within a given proximity to a public water supply may indicate a greater potential threat to the water supply.

The first indicator, total LUFT sites, is a broad measure of the status of our efforts to reduce the overall threat of this type of release to groundwater resources. Total LUFT sites is the total number of underground storage tank sites that have been found to be leaking and for which cleanup has not been completed. The second indicator, those LUFT sites located within 1,000 feet of public drinking water sources, is also a measure of our success at protecting groundwater quality and identifies the relative proportion of LUFT sites that may be an imminent threat to drinking water supplies.

What factors influence this indicator?

Currently, the total number of underground fuel tank sites is approximately 38,000. Of that 38,000, approximately 17,000 are identified as LUFT sites. The graph above indicates an increasing trend in LUFT sites between the years 1985 and 1995. The 1985 date represents the general period during which underground tank regulatory programs expanded at both the state and local government levels. Increased regulatory attention resulted in better accounting of the problem. The 1998 federal deadline for upgrading underground fuel tanks to current construction and monitoring standards is also a factor that likely contributed to the earlier increasing trend, as many tank owners discovered that their tanks had leaked during the upgrade activities. The sharp decrease in the number of total LUFT sites in approximately 1996 may correlate with the findings of studies that demonstrated that in most cases where the source of contamination has been removed, groundwater plumes of petroleum hydrocarbon constituents have not migrated great distances from the source due to attenuation processes (including biological degradation) acting on the contaminants. Based on these findings, many agencies closed numerous cases where the remaining contamination was stable and did not pose a threat to human health. Currently, with nearly all active tanks having been upgraded, the total number of LUFT sites should continue to decline.

With respect to the indicator involving proximity of underground tanks to public drinking water sources, the density of underground fuel tanks and public supply water wells closely correlates with areas of population densities. Addressing these sites is a high priority and an efficient evaluation may be conducted using the SWRCB's new environmental database, GeoTracker.

GeoTracker is a geographic information system (GIS) that provides online access to environmental data. GeoTracker is the interface to the Geographic Environmental Information Management System (GEIMS), a data warehouse which tracks regulatory data about underground fuel tanks, fuel pipelines, and public drinking water supplies. The centralization of environmental data through GeoTracker will facilitate more in-depth geospatial and statistical analysis in the future. This expansion in capabilities will greatly assist public agencies in planning and resource management.

Technical Considerations:

Data Characteristics

The data supporting these indicators are readily available on the GeoTracker database and have been collected as part of the Underground Storage Tank (UST) Program since 1980. Data supporting these indicators for LUFT sites in the Department of Defense program will be available in the 2001-2002 Fiscal Year. The spatial extent of groundwater plumes associated with this type of release is also captured in the "Groundwater Contaminant Plumes - Extent" environmental indicator.

Strengths and Limitations of the Data

GeoTracker uses commercially available software to allow users to access data from the Internet. The readily accessible database results in less duplication of effort and improved communication between stakeholders. The GeoTracker database is routinely updated and verified. Thus, the associated data are generally considered of good quality.

An accurate count of LUFT sites in a specific year requires knowledge of the site discovery date. In some cases (4000 records), the discovery date is unknown. In addition, the measurement of proximity of LUFT sites to water supply sources requires accurate data on locations of both the tanks and supply wells. Currently, the public water wells and LUFT positions are approximate. Locational accuracy is improving as state agencies and responsible parties obtain and report new and better information to the GeoTracker database.

For more information on the State Water Resources Control Board's Underground Storage Tank Program, please visit http://www.swrcb.ca.gov/cwphome/ust.

References:
GeoTracker: http://geotracker2.arsenaultlegg.com/

For more information, contact:
State Water Resources Control Board
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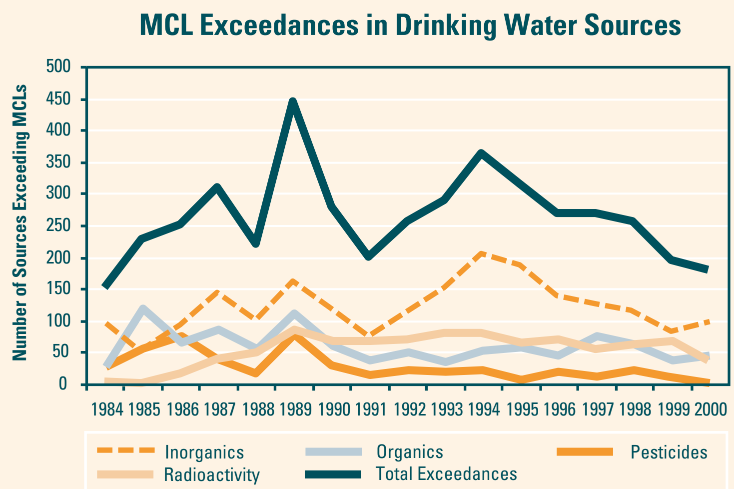
Drinking Water Supplies Exceeding Maximum Contaminant Levels (MCLS)

There is a slight decline in the overall low numbers of MCL exceedances in public drinking water sources.

Type I

Level 4
Goal 2, 3



What is this indicator showing?

Statewide monitoring of about 20,000 public water supply wells and surface water sources shows a slight decline in the overall low numbers of sources contaminated by naturally occurring and man-made substances.

Why is this indicator important?

This indicator shows the presence of regulated drinking water contaminants in wells and surface water sources belonging to public drinking water systems. It should not be considered a human health indicator since it is not an index of human exposure, because regulatory steps are taken to eliminate or minimize human exposure to drinking supplies with contaminants that exceed drinking water standards (called maximum contaminant levels or MCLs).

Public health agencies are concerned about contaminants in drinking water, particularly those that may affect the very young, or those that may cause reproductive effects, cancer, or other adverse effects. To protect the public health, the California Department of Health Services (DHS) has established MCLs, which are health-protective limits for a number of such contaminants in drinking water.

MCLs protect water consumers from adverse health effects associated with ingestion of 78 chemical contaminants and 6 radiological contaminants. Some of these contaminants may be naturally occurring, and some are the result of human activities.

Public water systems are required to routinely monitor their drinking water supplies on a regular basis for these contaminants. Additional standards and monitoring requirements exist for disinfection byproducts (the contaminants that are produced when water is treated by chlorination to remove microbiogical organisms, for example) and for lead and copper. Monitoring is also required for specific unregulated chemicals (currently nine are identified in DHS regulations); this enables DHS to collect information on the extent of their presence. Finally, when water systems' monitoring shows the presence of other unregulated contaminants, they must inform DHS of their findings. Such findings may result in the establishment of non-regulatory health-based advisory action levels, or in additional monitoring requirements. For some "new" contaminants, DHS may adopt regulations requiring monitoring, and in some cases, may adopt a new MCL. This is the process that was followed for the gasoline additive, methyl tertiary butyl ether (MTBE).

The monitoring that is conducted for purposes of complying with drinking water standards, whether from groundwater or surface water sources, allows for an evaluation of pollutants from contaminating activities or from natural sources, and elimination of potential pathways for human exposure to these contaminants. Monitoring also results in a body of data that can be examined as indicators of environmental pollution. In most cases, for example, for organic chemical contaminants pursuant to California regulations, monitoring occurs prior to any water treatment, though if treatment for a specific contaminant is required, monitoring occurs thereafter. Some chemicals are clearly related to treatment and are monitored after treatment, such as fluoride, where fluoridation occurs, and such as disinfection byproducts, which may result from chlorination.

The indicators presented here show contaminants in sources of drinking water supplies. They should not be viewed as contaminants that people have been drinking in their water. In practice, because public water systems may not serve water that exceeds health-based MCLs, except under rare conditions, the actual exposure to polluted drinking water may be reduced or eliminated by treating the water prior to service or by taking the source out of service.

For purposes of discussion, the various types of contaminants of concern to drinking water have been divided into four general categories: inorganic chemicals, organic chemicals, pesticides, and radioactivity.

What factors influence this indicator?

Contaminants in drinking water represent the environment from which the water is sampled. For example, contaminants such as arsenic, chromium, and radioactivity can reflect the geology of the area from which the water is drawn.

Drinking water well contamination can also result from contamination of soils and groundwater by human activities, including industry (e.g., trichloroethylene (TCE), a solvent used in the aerospace industry), commercial businesses (e.g., tetrachloroethylene (perchloroethylene, or PCE), a solvent used in dry cleaners), agriculture (e.g., 1,2-dibromo-3-chloropropane (DBCP), used in soil fumigation), and fuels (e.g., the gasoline additive MTBE, from leaking underground storage tanks). Surface water contamination can also result from chemical use (e.g., MTBE, from motorized boats and watercraft, or from gasoline spills from tanks or marine fueling stations).

Prevention of soil and groundwater contamination can be a very significant factor in preventing contamination of drinking water supplies. So, too, can prevention of contamination that may reach surface waters.

The sampling requirements can also influence these indicators. Over the past two decades, the number of regulated contaminants has increased markedly. This results in increased monitoring by public water systems. Similarly, monitoring requirements for unregulated chemicals (those without MCLs) have also resulted in more information being collected, and in some cases, new MCLs. Finally, improvements in laboratory analytical methods have made it possible to detect contaminants at lower levels — this may increase the number chemical detections. Such changes to the monitoring of public water supplies are anticipated to continue in the future.

The monitoring of water supplies by drinking water systems demonstrates that exceedances of MCLs on a statewide basis are relatively uncommon. However, even though statewide drinking water quality is good, on a localized basis, when an exceedance of an MCL occurs, it can be a very significant occurrence. If treatment is required, it may be expensive to the water system and to its customers. If treatment is not feasible, then the source of water may be lost to the community.

As mentioned above, drinking water MCL exceedances should not be interpreted as reflecting water being served, since wells may be treated or taken out of service, with no human exposure occurring. If such water is served, consumer notification is required.

The data show a slight decrease in the total MCL exceedances over the sampling period. Some improvements are apparent among organic and pesticide contaminants, likely reflecting improvements in industrial and agricultural practices that resulted in contamination several decades ago. MCL exceedances for inorganics and radioactive contaminants are flat, or even increasing, most likely influenced by changes in regulatory standards and monitoring requirements over the time period.

Exceedances by County

As of December 2000, the number of drinking water sources in the DHS database was over 25,000, with more than 20,000 sources identified as active and delivering water for public consumption. Of the state's 58 counties, each had at least one source that exceeded an MCL. The distribution of MCL exceedances differs among counties — for example, in Los Angeles County organic contaminant MCL exceedances account for 57 percent of the total, while pesticides account for 0.8 percent, while in Fresno County, organic MCL exceedances represent 7 percent of the total and pesticides account for 50 percent. The number of exceedances also reflects the counties' number of sources that are monitored, in that a county with many wells, for example, will monitor more wells than one with few wells.

Counties with the most sources that have exceeded an MCL since 1984 are presented below:

County	MCL Exceedances in Public Water Systems (1984-2000)				
	Total	Inorganic	Organic	Pesticide	Radioactivity
Los Angeles	1,148	415	653	9	71
San Bernardino	556	293	74	46	143
Kern	458	200	46	59	153
Riverside	344	181	23	36	104
Fresno	281	61	20	141	59
Stanislaus	205	58	8	57	82
Tulare	143	66	11	46	20
Santa Clara	109	96	5	0	8
San Joaquin	106	21	20	39	26
Ventura	105	72	6	2	25
Kings	74	32	19	3	30
Orange	70	49	11	1	9
San Diego	70	23	8	1	38
Monterey	66	41	13	0	12
San Luis Obispo	63	55	4	0	4
Sacramento	51	31	16	1	3
Sonoma	51	31	8	1	11
Merced	47	11	11	20	5
Others (39 counties)	504	307	78	18	92
Total	**4,452**	**2,043**	**1,034**	**480**	**895**

These general groups-inorganic and organic chemical contaminants, pesticides, and radioactivity-are discussed individually below.

Inorganic Chemical Contaminants:

This general category primarily consists of minerals that are naturally occurring, though some, such as arsenic and chromium, may also have commercial application. It also includes nitrates, which may reflect agricultural activities such as fertilizer application and confined animal feeding operations. It also includes some other substances such as cyanide (which may result from steel/ metal, plastic and fertilizer manufacturing) and unregulated inorganics such as the naturally occurring boron and perchlorate (from aerospace, fireworks, and munitions). Fluoride, which is the most frequently detected inorganic chemical, is naturally occurring, and it may also be added to drinking water in fluoridation programs.

The inorganic contaminants that have been detected most frequently are fluoride (11,917 sources), nitrate as NO_3 (9,263), arsenic (4,476), aluminum (3,213), boron (2,002), lead (1,393) and chromium (1,138).

Inorganic contaminant MCLs that have been exceeded most often are nitrate as NO_3 (964 sources), fluoride (350), aluminum (163), cadmium (119), and arsenic (128).

Organic Chemical Contaminants:

This general category contains primarily chemicals that are man-made and used in industry or commercially. This category does not include pesticides — data on pesticide MCLs are presented separately.

A number of chemicals in this category are byproducts of water treatment [i.e., chloroform (1,145 sources), bromodichloromethane (647), dibromochloromethane (619), (bromoform (602), dibromochloromethane, and dichlorodifluoromethane (119)].

The organic contaminants excluding disinfection byproducts most often detected include PCE (894 sources), TCE (808), 1,1,1-trichloroethane (195), 1,1-dichloroethylene (191), *cis*-1,2-dichloroethylene (168), 1,2-dichloroethane (119), and carbon tetrachloride (127), methylene chloride (87), MTBE (37), diethylhexylphthalate (DEHP) (29), and benzene (24).

Organic contaminant MCLs that have been exceeded most often are TCE (332 sources), PCE (271), 1,2-dichloroethane (119), carbon tetrachloride (127), 1,1-dichloroethylene (50), MTBE (23), benzene (21), *cis*-1,2-dichloroethylene (18), and DEHP (16).

Pesticide Contaminants:

This general category is primarily pesticides that are or have been used in agriculture. Several are no longer used, e.g., 1,2-dibromo-3-chloropropane (DBCP) (registration cancelled in the late 1970s), ethylene dibromide (EDB) (cancelled in the early 1980s), and 1,2-dichloropropane (cancelled in the mid-1980s).

For pesticide contaminants with MCLs, those that have been most often detected are DBCP (879 sources), EDB (77), 1,2-dichloropropane (56), atrazine (13), simazine (11), and bentazon (5).

Pesticide MCLs that have been exceeded most often are DBCP (405 sources), EDB (45), 1,2-dichloropropane (7) and simazine (1).

Radioactive Contaminants:

This general category contains radioactivity that is primarily naturally occurring in soils, and contributes to our natural background radiation exposure. One of the regulated radionuclides, strontium-90, is a fission product and a component of historic global fallout from above ground nuclear weapons tests.

Radioactive materials most often detected include gross alpha particles (8,267 sources) and gross beta particles (1,227 sources). These particles are very small emissions from certain radioactive elements, such as radium and uranium, which are alpha emitters, and tritium, which is a beta emitter. Alpha particles consist of 2 protons and 2 neutrons (i.e., a helium nucleus), while beta particles are smaller, the size of an electron.

Other detections include radon-222 (1,784), radium-226 and radium-228 combined (476), radium-226 (427), radium-228 (146), strontium-90 (55), and tritium (53).

During analyses, if the gross alpha particle MCL is exceeded, specific analyses for uranium and radium are performed. MCLs that have been exceeded most often are gross alpha particles (532 sources), uranium (243), radium-226 (48), radium-228 (47), and strontium-90 (11).

Recent Activities

As a result of new federal and state requirements, drinking water systems are required to provide an annual consumer confidence report (CCR) to their consumers. The CCR must include information about contaminants that are found in drinking water and their health significance.

To help protect drinking water supplies, DHS' Drinking Water Source Assessment and Protection (DWSAP) Program performs assessments that identify possible contaminating activities to which drinking water supplies may be vulnerable. The DWSAP Program also provides guidance and identifies potential funding sources for voluntary community-based activities to protect water supplies from future contamination.

For more information, see the DHS website at www.dhs.ca.gov/ps/ddwem/ and your drinking water system's annual Consumer Confidence Report.

Technical Considerations:

Data Characteristics

Over 873,000 initial analyses (i.e., the first analysis for a specific contaminant in a source) were performed from 1984 through 2000 by California's public drinking water systems. As of December 2000, the number of drinking water sources in the DHS database was over 25,000, with more than 20,000 sources identified as active and delivering water for public consumption.

The data presented here are in terms of first-time analyses, first-time detections and first-time MCL exceedances. Using "first-time" data eliminates the confounding of data interpretation by multiple detections and multiple MCL exceedances (since positive findings can result in more frequent sampling and therefore more detections). In some cases, raw and treated water from the same well or surface water source are in the database as separate entries.

Data for the four general categories were collected from a number of drinking water sources:

- Inorganic contaminants: Sampling occurred from 79 to 12,000 drinking water sources, depending on the particular contaminant being analyzed. The database contains positive findings for 25 different inorganic contaminants.

- Organic chemicals: 3 to15,000 drinking water sources depending on the particular contaminant being analyzed. The database contains positive findings for 50 different organic contaminants.

- Pesticides: 2,500 to 15,000 drinking water sources depending on the particular contaminant being analyzed. The database contains positive findings for 18 different pesticide contaminants.

- Radiological contaminants: 445 to 10,000 drinking water sources depending on the particular contaminant being analyzed. The database contains positive findings for 9 different radioactive contaminants.

Of the 20,000 sources identified as active and delivering water for public consumption, there are approximately 56,000 first-time detections and 4,452 first-time MCL exceedances. The overall numbers of analyses and findings are as follows:

Contaminant Type	Analyses	Detections	> MCL
Inorganic	156,838	34,427	2,043
Organic	476,164	7,224	1,034
Pesticide	221,311	1,069	480
Radioactivity	19,634	13,205	895
Total	873,947	55,925	4,452

The collection of data for regulated chemical contaminants is done according to schedules and procedures set forth in state regulations. The data are from drinking water systems that are regulated by DHS. Smaller systems that are regulated by local primacy agencies (usually county environmental health departments) have not been required to submit data to the DHS database, although regulatory changes in 2001 will result in those data being submitted to the DHS database. Additional data submissions may result in additional findings, which will not necessarily indicate an environmental change.

Private wells are not required to monitor for drinking water contaminants.

Strengths and Limitations of the Data

The body of data is dynamic, representing changes in the number of drinking water sources, changes in the contaminants for which monitoring is required, and changes in the reporting limit (related to the analytical detection limit). In addition, MCLs may be changed by regulatory action, or new MCLs may be adopted.

Because all drinking water sources are subject to repeated sampling and analyses, the data presented in this summary dealing with drinking water MCLs represent only the first time a chemical was sampled, detected, or found to exceed an MCL in a given source. Duplicate analyses or detections of a chemical in the same source are not included, ensuring that data from individual sources are included only once.

Reference:

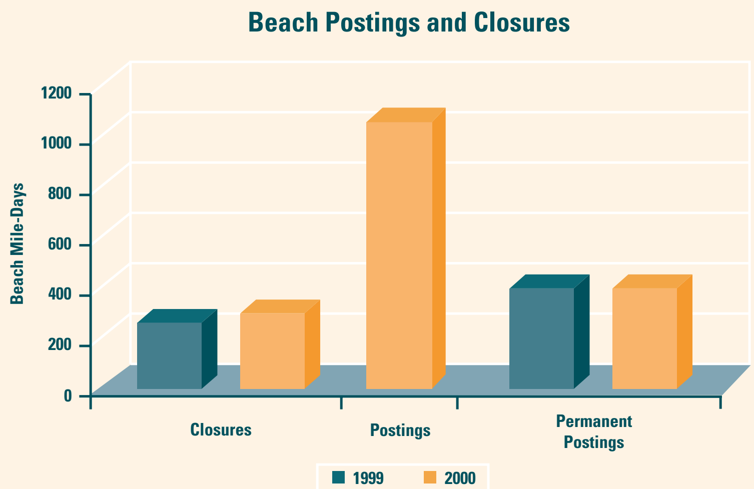
California Department of Health Services, Division of Drinking Water and Environmental Management. *Drinking Water Quality Monitoring Data (1984-2000)*. February 2001

For more information, contact:

Steven Book
Department of Health Services
P.O. Box 942732
Sacramento, California 94234-7320
(916) 323-6111
sbook@dhs.ca.gov

Coastal Beach Availability - Extent of Beaches Posted or Closed

Beach closures increased 15 percent from 1999 to 2000.



Type I

Level 4
Goal 2

What is this indicator showing?

The figure shows the number of coastal beach-mile days (BMD) posted and closed in 1999 and 2000. BMD is a measure of beach unavailability for swimming recreation each year. Closures increased 15 percent from 1999 to 2000. For 1999, new posting standards were implemented during the year; the partial year results are not shown.

Why is this indicator important?

Beaches, or more precisely the ocean waters adjacent to the beach, must be safe for swimming and other recreational use. When certain bacteria are present in sufficient concentrations, they may pose a health hazard for swimming. County health officers close or post beaches when certain kinds of bacteria are found in the water at levels that are considered a problem. These indicator bacteria imply the potential presence of microscopic disease-causing organisms originating from human and animal wastes. The total annual Beach Mile-Day (BMD) is a measurement of the magnitude of all ocean beach postings and closures for a year. BMD is the total number of miles of beaches posted or closed multiplied by the corresponding number of days of each beach posting or closure incident. Permanent postings are accounted for separately as they are in effect the entire year, often without monitoring.

What factors influence this indicator?

Beginning in 1999, AB 411 (Chapter 765, Statutes of 1997) required that local health officers conduct weekly bacterial testing (total coliform, fecal coliform, and enterococci bacteria) between April 1 and October 31, of waters adjacent to public beaches that have more than 50,000 visitors annually and are near storm drains that flow in the summer. If any one of these indicator organisms exceeds a standard the County health officer is required to post warning signs at the beach and to make a determination whether to close that beach in the case of extended exceedances. Closures are most commonly the result of sewage spills.

Much attention has been given to the number of beach closures and warnings (postings), especially along the southern California coast. California coastal communities have active monitoring programs conducted primarily by county health agencies and municipal waste treatment facilities. Water samples are collected in the surf zone to determine if recreational waters are contaminated with indicator bacteria (total coliform, fecal coliform, and enterococci bacteria). Studies have been conducted that correlate the levels of indicator bacteria with incidence of illness. If tests using indicator bacteria show levels above state standards, the beach will be posted with warning signs or closure notices to notify the public of the potential human health risk. The beach is reopened when further sampling confirms that bacteria levels meet state standards.

A beach closure occurs as a result of a sewage spill or repeated incidences of exceedances of bacteriological standards from an unknown source. A closure is a notice to the public that the water is unsafe for contact and that there is a high risk of getting ill from swimming in the water.

The posting of a warning sign means that at least one bacterial standard has been exceeded, but there is no known source of human sewage. The posting of a warning sign alerts the public of a possible risk of illness associated with water contact.

Many areas near storm drains, which often flow year-round, violate at least one of the bacterial standards on an ongoing basis. By convention, in southern California, all flowing storm drains are posted permanently. In many of these areas, sampling of water quality conditions is not conducted. Consequently, these permanent postings are separately accounted for in this indicator. Future reductions in permanent postings BMDs will occur with the implementation of measures such as the diversion of dry weather flows in storm drains.

Technical Considerations:

Data Characteristics

BMD is a measurement of beach availability. It is derived by multiplying two parameters that describe the magnitude of beach closures/postings in California: (1) number of miles affected; and (2) number of days during which ocean recreational waters are not available for swimming.

Strengths and Limitations of the Data

Annual BMD postings and closures are a useful measure for comparing the health of beaches from year-to-year. Other potential indicators such as number of incidents, the physical dimensions of each incident, or the number of days of postings or closures fall short of characterizing the full magnitude of beaches closures and postings in one measure.

Comparisons with beach monitoring data from the past is difficult. Before AB 411 became law, County health officers had discretion to sample waters and to post or close any beach that violated total coliform standards. Under the new regulations, health officers are required to sample and to post warnings whenever any one of the bacterial standards is violated. While health officers have the discretion for beach closures, they achieved consistency of closure actions throughout 1999 and 2000. Implementation of AB411 did not occur during the full calendar year of 1999. As such, drawing trends from 1999 to 2000 is appropriate for beach closures (which AB411 did not affect), but not for postings.

For the most part, this indicator reflects conditions of coastal beaches in southern California. The total availability of these waters is approximately 100,000 BMDs (no postings or closures for the year).

For more information on the SWRCB's Clean Beaches Initiative, please visit www.swrcb.ca.gov/beach/index.html.

Reference:

2000 California 305(b) Report on Water Quality. State Water Resources Control Board.

For more information, contact:

State Water Resources Control Board
Office of Statewide Initiatives
P.O. Box 944212
Sacramento, California 94244
(916) 341-5271

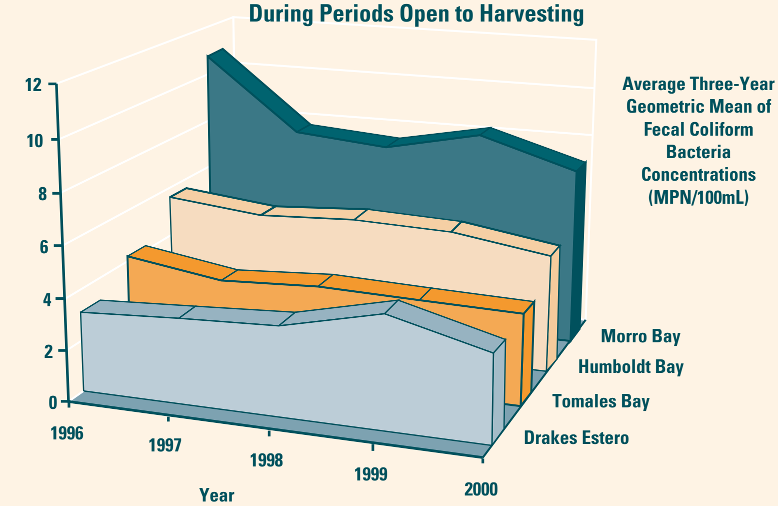
Type I

Level 4
Goal 2

Bacterial Concentrations in Commercial Shellfish Growing Waters

Water quality at four commercial shellfish growing areas continues to meet standards for bacterial contamination.

Average Three-Year Geometric Mean of Fecal Coliform Bacteria Concentrations in Approved Commercial Shellfish Growing Waters During Periods Open to Harvesting



What is the indicator showing?

The fecal coliform bacteria concentrations in approved commercial shellfish growing waters during periods open to harvesting continue to be maintained within the regulatory standard of 14 MPN (most probable number)/100 mL.

Bacterial contamination of shellfish has been a concern for consumers of shellfish. Monitoring of shellfish growing waters assures that the risk of a disease outbreak from the consumption of commercially harvested shellfish is minimized.

The fecal coliform concentration indicator is actually the arithmetic mean of the three-year geometric means for the individual shellfish growers within the specific water body that supports commercial shellfish growing. The arithmetic mean of the three-year geometric means serves as a measure for the overall bacteriological quality of the shellfish growing areas in the specific water body. As an average, the measure can be used for general comparisons with the regulatory standard.

What factors influence this indicator?

Fecal coliform bacteria concentrations are monitored in approved commercial shellfish growing waters during periods open to harvesting. Low fecal coliform bacteria concentrations in approved commercial shellfish growing waters during periods open to harvesting imply a corresponding low bacteriological contamination of the meats of harvested shellfish. The indicator shows there have been no exceedances of the regulatory standard for fecal coliform bacteria in the approved shellfish growing waters during the period of 1996 through 2000.

Water quality tends to be worse during periods when shellfish are not harvested and monitoring is not conducted. As a result, water quality, as reflected by fecal coliform counts during these periods, would not be represented by these data.

The regulatory standard for approved shellfish growing waters during periods open to harvesting is based on the geometric mean of fecal coliform bacteria of monthly samples taken over the most recent three-year period. When this regulatory standard is exceeded, further restrictions to harvesting are placed on approved commercial shellfish growers. Ongoing evaluations of three-year geometric means relative to the regulatory standard are conducted to assess the effectiveness of these restrictions on improving the bacteriological qualities of approved shellfish growing waters during periods open to harvesting. As a result, ongoing changes in these restrictions will tend to lower the fecal coliform bacteria concentrations and the three-year geometric mean. This measure has been collected consistently for several years to meet regulatory requirements and represents trends in the quality of the water used for growing shellfish.

Technical Considerations:

Data Characteristics

The regulatory standard of a fecal coliform bacteria concentration of 14 MPN per/100 milliliter (mL) was established through a U.S. Public Health Service review of epidemiological investigations of shellfish-caused disease outbreaks which occurred from 1914 to 1925, a period when disease outbreaks attributable to shellfish were more prevalent. MPN refers to the Most Probable Number, as determined by a specific assay. The review indicated that typhoid fever and other enteric diseases would not ordinarily be attributed to shellfish harvested from water in which the estimated fecal coliform concentration was lower than 14 MPN/100 mL, provided the shellfish growing areas were not subject to direct contamination with small amounts of fresh sewage which would not be revealed by bacteriological examination.

Approved commercial shellfish growers are required to collect monthly water quality samples using appropriate sampling methodologies in the growing areas during periods open to harvesting. These samples are sent to appropriately certified laboratories and are analyzed for fecal coliform bacteria concentrations using appropriately approved methods. Data collection is conducted using methodologies that yield data that are clearly defined, verifiable, and reproducible. As a result, the indicator will reflect any significant trends in the approved commercial shellfish growing waters' ability to meet regulatory standards. Shellfish harvested from these beds include: Pacific oysters, Kumamoto oysters, Eastern oysters, European oysters, Manila clams, Bay mussels and Mediterranean mussels.

Strengths and Limitations of the Data

Approved commercial shellfish growers collect monthly water quality samples only during periods open to harvesting. As a result, the monthly data do not represent water quality in approved commercial shellfish growing waters during periods closed to harvesting. Harvesting in these areas is generally closed during periods of likely adverse pollution events, such as heavy rainfall, sewage spills, and other potentially significant releases of contaminants to the shellfish growing waters.

Finally, fecal coliform bacteria concentrations are used only as a general indicator of contamination by potential pathogenic microorganisms. The fecal coliform bacteria concentration results may not provide sufficient indication of contamination by other pathogenic microorganisms, such as viruses and other pathogenic bacteria.

References:

Triennial Sanitary Survey Update Reports (for commercial shellfish growing areas in California)

For more information, contact:

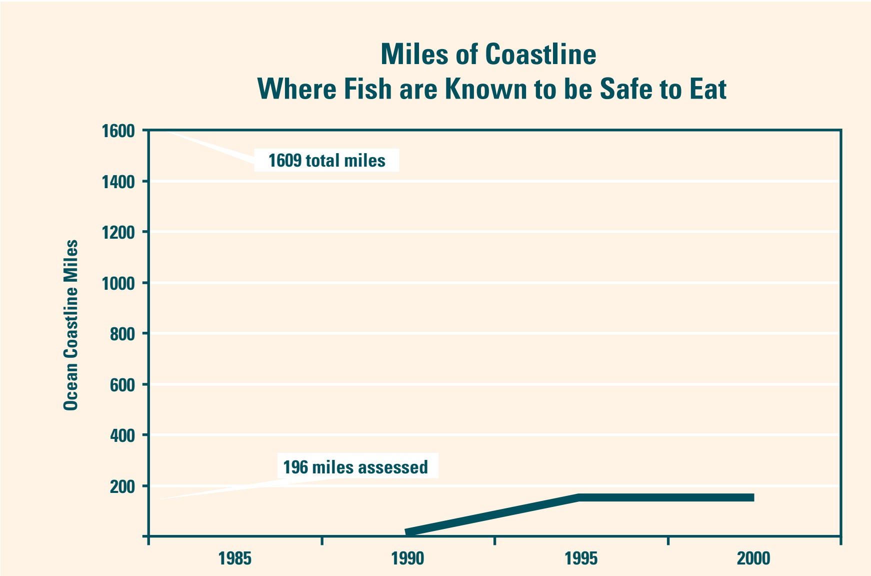
Department of Health Services
Drinking Water and Environmental Management Division
P.O. Box 942732
Sacramento, California 94234-7320
(916) 327-5590

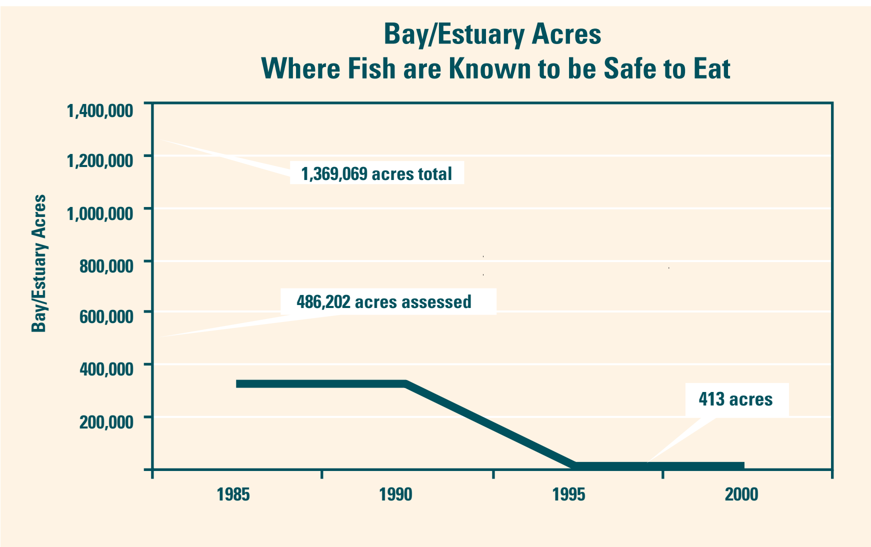
Fish Consumption Advisories - Coastal Waters

The extent of coastal waters where fish can be safely eaten is being maintained in the coastal areas and is decreasing for bay/estuary areas.

Type I

Level 5
Goal 2





What is the indicator showing?

The ocean waters assessed to determine the safety of consuming fish are a small fraction of all waters where fishing occurs. The data indicate that, for total miles of coastline assessed, areas available for safe fish consumption are being maintained. In contrast, data for bays and estuaries indicate that areas available for safe fish consumption have decreased.

Why is this indicator important?

This indicator shows the extent of coastal waters (coastline and bay/estuary) where it is safe for the general population to consume the fish they catch. The Office of Environmental Health Hazard Assessment's (OEHHA) Coastal Fish Contamination Program provides ongoing monitoring and assessment of the potential human health effects from consuming sport fish caught in coastal waters.

Recreational fishing is an important beneficial use of water. Water bodies used for recreational fishing must be "fishable" (i.e., people should be able to consume the fish they catch without appreciable health risk). OEHHA issues fish consumption advisories, providing recommendations on fish consumption limits, where there is a potential human health risk related to sport fish consumption. This indicator uses OEHHA's determination that the general public can eat at least one meal a week of the sport fish they catch from a water body to identify coastal water bodies where fish are "known" (because they have been tested and health effects evaluated) to be safe to eat. Water bodies for which there is insufficient fish monitoring data available to determine whether there is a human health risk are not included in this indicator. As the area of coastal waters for which it is known that fish are safe to eat increases, fewer people fishing in coastal waters will be exposed to potential human health risks due to the accumulation of chemicals in the sport fish they catch.

This indicator shows that the extent of ocean miles where it has been demonstrated that it is safe for the general public to eat fish once a week increased from 1990 to 1995 and remained the same in 2000. In contrast, this indicator shows that the extent of bay and estuary acres where it is safe for the general public to eat fish once a week decreased in this time period.

What factors influence this indicator?

Past studies and ongoing monitoring of chemicals in fish have been used by OEHHA to perform risk assessments and issue public advisories to stop or reduce consumption of sport fish where the chemical levels in fish might adversely affect human health when eaten for a lifetime. This indicator is highly dependent on the extent of monitoring and the frequency of reassessment. Assessments have been conducted in a limited number of waters. Thus, care should be exercised in drawing conclusions from this indicator.

Trends in the past 15 years reflect, in part, changes in monitoring and assessment. The Coastal Fish Contamination Program, which began in 1999, is providing monitoring data for assessing all fishable coastal areas. This program is generating a baseline against which future changes can be measured.

Technical Considerations:

Data Characteristics

Fish caught from water bodies used for recreational fishing are analyzed for appropriate chemical contaminants following guidelines that will ensure that the chemical concentration data can be used for human health risk assessment. Most fish consumption advisories in California are due to mercury, PCBs, or chlorinated pesticide contamination in fish. OEHHA establishes guidelines and sampling plans in conjunction with the State Water Resources Control Board, the Regional Water Quality Control Boards and the California

Department of Fish and Game. Typically, the Department of Fish and Game collects and analyzes fish, although other agencies and laboratories may also do so. Data on water body collection site, water body size (in miles or acres), fish species, number of fish collected, fish length and weight, lipids, and chemical concentrations in tissue are needed as part of the risk assessment. Chemical concentrations are expressed as wet weight concentrations and are used to determine whether there is a potential health risk from fish consumption and how many meals it is safe to consume. Up-to-date toxicologic information is also needed for human health assessments. Water bodies are only assessed when sufficient data of good quality are available.

Strengths and Limitations of the Data

The strength of this indicator is that the basic measure (the safe consumption of frequently caught sport fish species) is easy to understand, is based on scientific data subject to quality control, and integrates several more complex concepts (e.g., chemical levels and risk assessment). Fish data also have the advantage of integrating chemical exposure over space and time and from different media (water and sediment) into a single indicator of water quality.

The primary limitation of this indicator is that much of the State's coastal water bodies have not been assessed. Hence, this indicator is not based on a large database and is not currently representative of the entire state. OEHHA's assessments cover 196 miles of coastline (of the 1,609 total miles) and 486,202 acres of bays and estuaries (of the 1,369,069 total acres). To date, 12 advisories have been issued for coastal waters. The relatively new Coastal Fish Contamination Program will greatly improve the extent of coastal areas monitored and assessed for potential human health effects from eating California sport fish. The program uses a five-year monitoring and assessment cycle. Thus, it will require additional time to complete all coastal areas. Initially the program will focus on identifying and assessing priority water bodies. Therefore, early results may show little increase in safe areas, but will assess a greater area. This is likely to change as all areas are monitored and assessed.

New developments in toxicological research can result in fish consumption advisory changes for a particular water body, regardless of changes in the chemical concentration in water or fish, and are not necessarily indicative of a change in water quality. Additionally, this indicator may not show small changes in chemical concentrations because not all changes are significant enough to warrant different consumption advice. Finally, on a statewide basis, this indicator may be less sensitive to changes in water bodies with a small area, than large water bodies.

Fish Consumption Advisories for California Coastal Waters

Water Body	Contaminant	Fish With Restricted Consumption
San Francisco Bay and Delta	Mercury, PCBs and other chemicals	All fish except salmon, anchovies, herring, and smelt
Point Dume/Malibu off shore	PCBs and DDT	White Croaker
Malibu Pier	PCBs and DDT	Queen Fish
Short Bank	PCBs and DDT	White Croaker
Redondo Pier	PCBs and DDT	Corbina
Point Vicente, Palos Verde-Northwest	PCBs and DDT	White Croaker
White' s Point	PCBs and DDT	White Croaker, Sculpin, Rockfishes, Kelp Bass
Los Angeles/Long Beach Harbor (esp. Cabrillo Pier)	PCBs and DDT	White Croaker, Queenfish, Black Croaker, Surfperches
Los Angeles/Long Beach Breakwater (Ocean Side)	PCBs and DDT	White Croaker, Queenfish, Black Croaker Surfperches
Belmont Pier, Pier J	PCBs and DDT	Surfperches
Horseshoe Kelp	PCBs and DDT	White Croaker, Sculpin
Newport Pier	PCBs and DDT	Corbina

References:

State Water Resources Control Board. *2000 California 305(b) Report on Water Quality.*

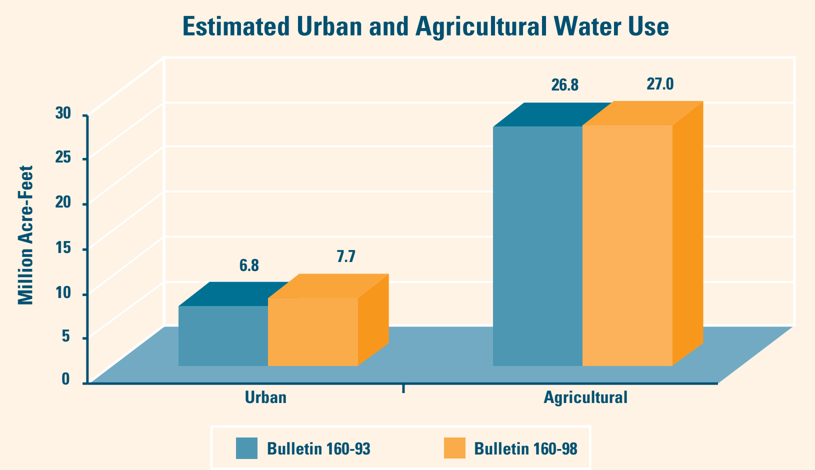
Office of Environmental Health Hazard Assessment. *California Fish Consumption Advisories.* Posted at: www.oehha.ca.gov/fish/general/99fish.html

For more information, contact:

Robert Brodberg
Office of Environmental Health Hazard Assessment
Pesticide and Environmental Toxicology Section
P.O. Box 4010
Sacramento, California 95812-4010
(916) 323-4763

Statewide Water Use And Per Capita Consumption

Urban water uses are growing at a faster rate than agricultural uses.



Type I

Level 3
Goal 6

What is the indicator showing?

This indicator shows that while urban uses are increasing as the population grows, agricultural uses are leveling off due to land conversions and other causes.

Why is this indicator important?

This indicator reflects trends in the interplay between the statewide urban and agricultural water uses. These and a third sector (environmental water use) largely consume all of the fresh water accounted for by the Department of Water Resources (DWR) in its periodic California Water Plan Updates. Total urban water use is increasing as urban populations are increasing. Agricultural water use is leveling off largely as the result of conversion of agricultural land for urban expansion. (DWR long-term forecasts are for a decline in agricultural water use.)

What factors influence this indicator?

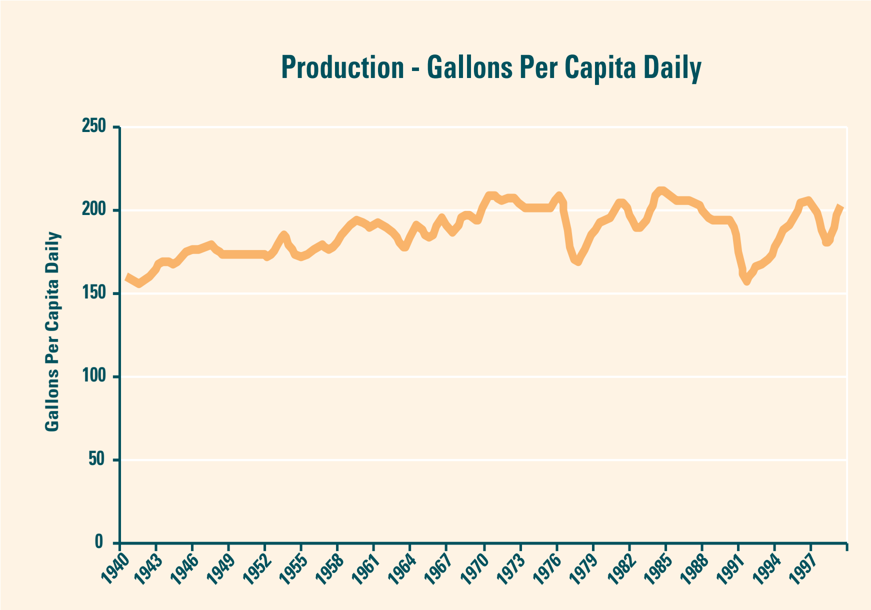
This indicator is drawn from the 1990 and 1995 base case scenarios developed for the 1993 and 1998 California Water Plan (CWP) Updates. These updates are intended to enable informed decisions for water supply and use management at local, regional, statewide, and national levels of government. Published as the Bulletin 160 series, the CWP Update is on a five-year issuance cycle. For each CWP Update, DWR with input from a Public Advisory Committee addresses key factors that affect water demands, such as population growth, climate change, changes in land uses, socioeconomic conditions and markets for California products. These factors may change with each update. In addition, each update incorporates new methods in data management and evaluation.

The 1957 CWP and its seven subsequent updates (Bulletin 160 series) include water budget information for both existing and future needs. Water supplies and uses are not equally distributed across the state. Generally, the northern Sierras generate abundant surface runoff, but major agricultural and urban uses are in the Great Central Valley and coastal regions. Costs to transfer water between regions are generally borne by the users. Regional self-sufficiency is an emerging concern. Each CWP Update discusses both statewide and regional water budgets.

Urban water use includes residential, commercial, industrial, and institutional uses of water. Each of these categories can be examined at a greater level of detail, such as interior and exterior residential use. Many factors may influence rates of urban per capita water use, such as water pricing by the retail water purveyor, seasonal weather, and the implementation of water conservation measures.

Agricultural water use is estimated by multiplying water use requirements for different crop types by their corresponding irrigated acreage, and summing the totals. Agricultural water use may be influenced by crop cultural practices, seasonal rainfall, water pricing, and water use efficiency measures, among other factors.

The figure that follows shows statewide historical per capita urban water production. (Per capita production is the water provided by urban suppliers, divided by population. Urban water production is not the same as total urban water use. Total use includes self-produced supplies, water for recreation and energy production uses, and losses from major conveyance facilities.) After the severe but brief 1976-77 drought, statewide urban per capita water production rates returned to pre-drought levels within three to four years. During the longer 1987-92 drought, urban per capita water production rates declined by about
19 percent on the average statewide. (Most requirements for water-conserving plumbing fixtures did not take effect until after the 1987-92 drought.) The Department's data show increases in per capita water production following the drought, due to removal of mandatory water rationing and other short-term restrictions. When viewed at a statewide level, the data show a strong response to hydrologic conditions.



Technical Considerations:

Data Characteristics

To the extent data are available, the CWP Update addresses water deliveries by source (see California's water supplies with existing facilities and programs in the Background Indicators section) as well as water uses by sector. Historical water information is developed at detailed local levels, then aggregated regionally and statewide. Some of the basic data sets incorporated into this indicator include historical urban water production by urban water purveyors, surveys of irrigated agricultural acreage and other land uses, and groundwater usage. Sampling techniques and direct surveys are among the basic data development methods used to gather information on state water uses and deliveries. Certain data sets are unique, and developed directly for the CWP Update, while others are "imported" from other agencies, such as population information from the Department of Finance and the U.S. Census Bureau.

The two most recent CWP Updates have also included dry year and normal hydrology year scenarios for the base and forecast water balances. Recent amendments to the enabling statutes in the California Water Code have prescribed the water supply and demand management parameters to be analyzed by the CWP Update, starting with the 2003 issue.

References:

California Department of Water Resources
California Water Plan (Bulletin 3)
California Water Plan Update (Bulletin 160 Series)
www.waterplan.water.ca.gov

For more information, contact:

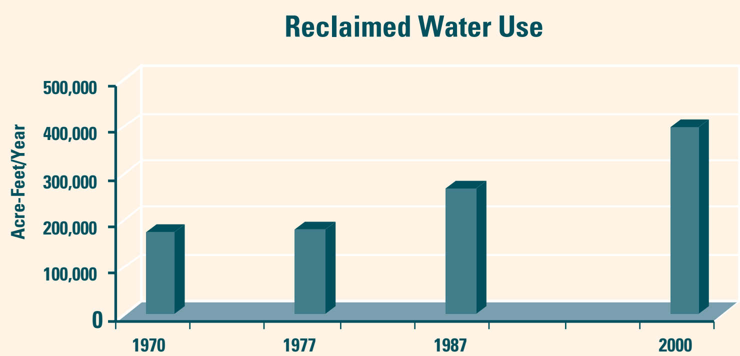
Department of Water Resources,
Statewide Water Planning Branch
P.O. Box 942836
Sacramento, California 94236-0001
(916) 653-5666

Type I

Level2
Goal 6

Water Use Efficiency - Recycling Municipal Wastewater

The amount of municipal wastewater recycled annually is increasing.



What is the indicator showing?

Wastewater recycled at municipal wastewater treatment plants increased by 50 percent in 13 years. In 2000, the amount of recycled water was equivalent to the annual water supply needs of over 1,600,000 people.

Why is this indicator important?

Municipal wastewater, collected and treated, can be directly used for a variety of beneficial uses, depending on the quality of the effluent achieved and the various water demands. These uses include agricultural and landscape irrigation, industrial cooling water, recreational, wildlife habitat and other uses. This indicator shows the amount of municipal wastewater reclaimed and directly put to beneficial use. Reclaimed water, also called recycled water, means water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur. Increases in the amount of water recycled increase the state's overall water supply capacity.

What factors influence this indicator?

For 2000, the estimated total amount of treated municipal wastewater that is being recycled is 402,000 acre-feet per year. This represents a 50 percent increase from a survey conducted 13 years ago by the State Water Resources Control Board (1987). The wastewater is produced by 234 treatment plants and is being reused at approximately 4,840 sites. Statewide, roughly 80 percent of wastewater reclamation is done by 20 percent of the treatment plants involved in reclamation. Additional details are available in the survey (see References), also posted at www.swrcb.ca.gov.

The amount of wastewater reclaimed in 2000 approximates the annual water supply needs of approximately 1,600,000 people (based on 1995 estimates by the Department of Water Resources of 229 gallons per capita per day in 1995). This is equivalent to the combined water storage capacity of Castaic Reservoir and Big Bear Lake in southern California. It is also equivalent to the storage capacity of four reservoirs the size of Los Vaqueros in the San Francisco Bay region.

The state has a goal of reclaiming one million acre-feet/year of wastewater by 2010.

Technical Considerations:

Data Characteristics

The State Water Resources Control Board conducted a comprehensive survey of water reclamation in California for the year 1987. It was accomplished by a mass mailing of a detailed questionnaire to all known agencies producing reclaimed water for reuse. The year 2000 survey used a new approach. It is part of an on-going survey in which the data for agencies will be updated at differing frequencies depending on the amount of reuse and the anticipated rate of changes expected. Thus, each year, many of the large reclamation projects will be resurveyed and new projects will be added. The remaining projects will be resurveyed at longer intervals, perhaps up to five years. In this way, the survey at any given time will provide a reasonable estimate of the total reuse occurring. Because of this approach, many of the smaller projects and some larger projects are still based on 1987 data.

Strengths and Limitations of the Data

Much of the updated information was obtained by use of a questionnaire. However, additional data sources include annual monitoring reports submitted by the reclaiming entities to the Regional Water Quality Control Boards, annual reports submitted on completed water reclamation projects funded by the State Water Resources Control Board, telephone interviews, and review of waste discharge or reclamation requirements. Another important source is the Annual Status Report on Reclaimed Water Use, which is issued by the County Sanitation Districts of Los Angeles County and provides reuse information at ten District plants.

A substantial amount of unplanned reuse occurs throughout California, either through diversions from streams downstream from wastewater discharges or from percolation of treated wastewater in stream beds. This indicator does not include unplanned (and often difficult to quantify) reuses. For example, the percolation of effluent through rapid infiltration, as in ponds, intended primarily as a method of wastewater treatment and disposal, is not considered planned reuse. Planned reuse is the deliberate direct or indirect use of reclaimed water without relinquishing control over the water during its delivery.

A significant component of groundwater supply for some communities involves the indirect reuse of effluent percolated in stream beds. Indirect reuse is the use of reclaimed water indirectly after it has passed through a natural body of water after discharge from a wastewater treatment plant. These indirect uses are not included in this indicator.

Beyond the scope of this indicator are other activities, which in effect reclaim wastewaters, or polluted waters. These include the downstream reuse of agricultural drainage water and the remediation of polluted groundwaters.

References:

California State Water Resources Control Board, Office of Water Recycling. *California Municipal Wastewater Reclamation Survey.* May 24, 2000

For more information, contact:

State Water Resources Control Board
Office of Water Recycling
P. O. Box 944212
Sacramento, California 94244
(916) 341-5739

Type II

Groundwater Contaminant Plumes - Extent

The extent of groundwater contaminant plumes represents an integrated spatial view of the threat to groundwater resources resulting from various sources of pollution. These specific sources of pollution are discussed in related environmental indicators pertaining to groundwater including Leaking Underground Fuel Tank (LUFT) sites. This indicator will provide a comprehensive measure of the overall effect of contamination on groundwater quality over time. However, at this time, the data for the indicator have not been assembled into a useable format.

Groundwater contaminant plumes result from a variety of sources including leaking landfills, leaking underground storage tanks, and other unauthorized releases of contaminants to groundwater. Characterizing the extent of a groundwater contaminant plume requires knowledge of the site hydrogeology, as well as sufficient site characterization and monitoring data. Changes in the extent of groundwater contaminant plumes, as well as the temporal trends in concentrations of contaminants in groundwater monitoring wells, reflect changes in groundwater quality over time. Once the extent of a groundwater contaminant plume has been characterized, an assessment of the real and/or potential threat to receptors may be evaluated. In addition, tracking changes in the extent of groundwater contaminant plumes over time enables resource managers to assess plume stability and the overall impact to groundwater quality.

The extent of groundwater contaminant plumes is defined in several State Water Resources Control Board (SWRCB) and Regional Water Quality Control Board (RWQCB) programs, such as the Department of Defense (DOD) Program, the Spills, Leaks, Investigations, and Cleanup Program (SLIC) Program, the Land Disposal Program, and the Underground Storage Tank (UST) Program. A majority of the data regarding the spatial extent of groundwater contaminant plumes are collected by responsible parties in response to regulatory requirements and kept in program site files at the various RWQCB offices. Although most of the data are in hard copy format, the San Francisco Bay RWQCB has conducted a successful pilot study to obtain groundwater contaminant plume data in digital format. Spatial data are most effectively displayed and analyzed using a geographic information system, such as the SWRCB's GeoTracker system, geotracker.swrcb.ca.gov/.

For more information, contact:

State Water Resources Control Board
Division of Clean Water Programs
P. O. Box 944212
Sacramento, California 94244
(916) 341-5700

Contaminant Release Sites

Type II

The total number of contaminant release sites (not regulated as part of the Underground Storage Tank Program, which is addressed as a separate indicator) indicates an impact to groundwater resources. A subset of this indicator, contaminant release sites located within 1,000 feet of public drinking water sources, measures the relative proportion of these sites that may pose an imminent threat to drinking water supplies. However, at this time, the data have not been assembled into a useable format.

Contaminant release sites may impact groundwater resources and include leaking landfills, contaminant release sites at military facilities; chemicals spilled onto the ground during storage, transport or disposal; percolation of pollutants from illegal dumping of hazardous substances and waste materials; and leakage through the soil from improperly lined waste disposal ponds, sumps, and industrial leach fields. These types of contaminant release sites are regulated by the State Water Resource Control Board (SWRCB) and nine Regional Water Quality Control Boards (RWQCB) in the Land Disposal, Department of Defense (DOD), and Spills, Leaks, Investigations, and Cleanup (SLIC) Programs. Sites are identified through investigations of contaminated drinking water wells, public complaints, groundwater monitoring and routine environmental sampling, referrals from other agencies, and disclosures from responsible parties.

Leaking landfill site data are discussed in the 1989 SWRCB Solid Waste Assessment Test (SWAT) Report. State and Regional Board staff manage landfill data using the SWRCB's System for Water Information Management (SWIM) database. Currently, the data in SWIM are incomplete and undergoing improvement. In addition, SWRCB is initiating the collection of accurate landfill geographical data using global positioning system (GPS) receivers. There is also an effort to track other contaminant release sites in the Spills, Leaks, Investigations, and Cleanup Program database that includes geographical information. The distance between contaminant release sites and water supply sources will be displayed on the SWRCB's GeoTracker Internet site, as soon as accurate geographical information is obtained. The extent of groundwater plumes associated with these types of contaminant release sites are captured in the "Groundwater Contaminant Plumes" environmental indicator.

References:

State Water Resources Control Board. *Solid Waste Assessment Test (SWAT) Report.* 1989

State Water Resources Control Board. SWIM Database, posted at: oitweb/oit/html/swim.htm

State Water Resources Control Board. GeoTracker System, posted at: geotracker.swrcb.ca.gov/

For more information, contact:

State Water Resources Control Board
Division of Clean Water Programs
P. O. Box 944212
Sacramento, California 94244
(916) 341-5700

Type III

Fish Consumption Advisories - Inland Waters

Recreational fishing is an important beneficial use of water. Chemical contaminants in water bodies can accumulate in fish and shellfish to levels that make them unsafe to eat. This indicator is analogous to the "Fish Consumption Advisories - Coastal Waters" but is expressed separately here for inland river and lake areas since there is substantially less information to characterize rivers and lakes than there exists for coastal waters. Furthermore, there is no formal program to monitor rivers and lakes, as there is for coastal areas. The indicator is highly dependent on the extent of monitoring and the frequency of reassessment. Currently, the inland waters assessed to determine the safety of consuming sport caught fish are a very small fraction of all waters where fishing occurs. Nevertheless, the assessed waters show a trend toward an increased area of lakes and rivers where the general public can safely eat at least one meal a week of the sport fish they catch from a water body.

Assessments conducted by the Office of Environmental Health Hazard Assessment (OEHHA) cover 202 miles of perennial river (out of 64,438 total miles) and 289,717 acres of lake (out of 2,086,230 total acres, including saline lakes). To date, 14 advisories have been issued for inland waters. Data indicate that the amount of lake acres where it is demonstrated that fish can be safely consumed once a week increased from 1985 to 2000 (from about 5400 acres to about 70000 acres, respectively). The extent of river miles where a meal a week can be safely eaten also increased during this time (an increase from 0 to 50 miles, respectively, from 1985 to 2000). Sport fishers may be concerned, despite the positive trend, because so little river and lake area in the state has been assessed. A program similar to OEHHA's Coastal Fish Contamination Program is needed to collect the data necessary to make this a useful indicator. Without a dedicated program, this indicator can only be updated when special or one-time studies generate adequate data for assessment of rivers or lakes.

Fish Consumption Advisories for California Inland Waters

Water Body Name	Contaminant	Fish With Restricted Consumption
Lake Herman	Mercury	Largemouth Bass
Guadalupe Reservoir	Mercury	All fish
Calero Reservoir	Mercury	All fish
Almaden Reservoir	Mercury	All fish
Guadalupe River and associated percolation ponds	Mercury	All fish
Guadalupe Creek and associated percolation ponds	Mercury	All fish
Alamitos Creek and associated percolation ponds	Mercury	All fish
Lake Nacimiento	Mercury	Largemouth Bass
Harbor Park Lake (Machado Lake)	Chlordane and DDT	Goldfish, Carp
Clear Lake	Mercury	Largemouth Bass, White Catfish, Channel Catfish, Brown Bullhead, Blackfish, Crappie and Hitch
Lake Berryessa	Mercury	Largemouth Bass, Smallmouth Bass, White Catfish, Channel Catfish, Rainbow Trout
Grasslands Area	Selenium	All fish
Salton Sea	Selenium	Croaker, Orangemouth Corvina, Sargo, and Tilapia
Lake Pillsbury	Mercury	All fish

References:

State Water Resources Control Board. *2000 California 305(b) Report on Water Quality.*

Office of Environmental Health Hazard Assessment, California Fish Consumption Advisories, posted at: www.oehha.ca.gov/fish/general/99fish.html

For more information, contact:

Robert Brodberg
Office of Environmental Health Hazard Assessment
Pesticide and Environmental Toxicology Section
P.O. Box 4010
Sacramento, California 95812-4010
(916) 323-4763
rbrodber@oehha.ca.gov

Type III

Groundwater Supply Reliability

This indicator would provide an estimate of the amount of groundwater available for long-term extraction, in acre-feet per year, without causing adverse effects. The indicator would be used to help determine whether or not our current groundwater supplies are sufficient in quantity to meet future demands. It is important to identify the amount of groundwater available to meet future demands in order to avoid unacceptable extraction amounts and to plan future water management strategies for meeting water-related beneficial uses in California.

The groundwater available is determined by Basin Management Objectives (BMOs) for each basin and sub-basin in the state. These BMOs would identify threshold values at which groundwater extraction would be terminated. Threshold values would be identified for groundwater level in the aquifer, water quality conditions, and land surface subsidence. The BMOs may be implemented by groundwater management plans or ordinances, and also include other environmental and institutional factors.

Main data sources are Department of Water Resources monitoring wells, U.S. Geological Survey information, and local agency monitoring programs. Available information includes: a) groundwater levels in wells, seasonal data collected at a minimum in the fall and spring, b) groundwater basin geology, collected from existing maps, published reports, and well completion reports, and c) basin water budgets, data from extraction records, water demands by land use, known recharge, and estimated recharge.

The indicator cannot be presented because there are over 500 basins and sub-basins in California which vary in the amount of data available and adequacy to present an indicator. In addition, BMO objectives have not been identified for many basins.

For more information, contact:
Department of Water Resources
Statewide Water Planning Branch
Division of Planning and Local Assistance
P.O. Box 942836
Sacramento, California 94236-0001
(916) 653-9493

Land, Waste and Materials Management

Introduction

The use of materials, both raw and manufactured, leads to the generation of waste. Population size, economic activity, and the consumption of products are significant factors in the production of waste. California, as both the most populous and economically prosperous state in the nation, is faced with the challenge of managing its waste in an environmentally sound manner. Waste is a pressure on the environment — in terms of the loss of land and other resources necessary for its disposal or treatment, and of the environmental contamination that may potentially result from its treatment, storage, disposal and other handling. Radioactive wastes and infectious wastes are not addressed in this report.

The term "solid waste" means all putrescible and nonputrescible solid, semisolid and liquid waste, including garbage; trash; refuse; paper; rubbish; ashes; industrial wastes; demolition and construction wastes; abandoned vehicles and parts; discarded home and industrial appliances; dewatered, treated, or chemically fixed sewage sludge which is not hazardous waste; and manure, vegetable or animal solid and semisolid wastes. "Hazardous waste" is waste that is ignitable, corrosive, reactive or toxic, or that is listed as such due to its known hazardous characteristic or because the process that generates it is known to produce hazardous waste. California's definition of a hazardous waste is more stringent than the federal government's. Hence, certain wastes that are not regulated as hazardous under federal law are subject to California hazardous waste requirements. These are commonly referred to as "California-only" hazardous wastes.

Land, Waste and Materials Management Indicator

Waste generation

Waste generation, in general

Statewide solid waste generation, disposal and diversion, per capita (Type I)

Number of tires diverted from landfills (Type I)

Hazardous waste shipments (Type I)

Federal and California-only hazardous waste generation (Type II)

Accidents/disasters/spills/releases

Hazardous material incidents (Type I)

Waste importation/exportation

Hazardous waste imported/exported (Type II)

Disposal to land

Statewide solid waste disposal per capita (Type I)

Hazardous waste disposal (Type I)

Site contamination

Cleanup of illegal solid waste disposal sites (Type II)

Tire cleanup (Type II)

Soil cleanup (Type I)

Contaminated sites (Type I)

Cross-media contamination

Number of environmental releases from active landfills (Type III)

Groundwater contaminant plumes - Extent (see Water section)

Contaminant release sites (see Water section)

California began regulation of hazardous waste in the 1970s, and now operates a regulatory system more stringent than the federal system. The Department of Toxic Substances Control (DTSC) is responsible for administering the state's programs for regulating the management of hazardous waste, and for conducting and overseeing the cleanup of contaminated sites. In the past decade, increasing emphasis has been placed on pollution prevention efforts, particularly those aimed at hazardous waste reduction. In 1985, DTSC established a hazardous waste source reduction program, and in 1989, California became one of the first states to enact facility source reduction planning legislation. Subsequent legislation expanded the Department's pollution prevention programs.

The 1990 Integrated Waste Management Act created the California Integrated Waste Management Board (CIWMB), and set the stage for a series of statewide reforms in waste management. Among other things, this legislation established a 50 percent goal for solid waste diversion from landfills for local government, based on an integrated waste management hierarchy that emphasized waste reduction and recycling over all other options. In 2000, California diverted more than 42 percent of its solid waste. This is a tremendous accomplishment. The CIWMB strives to support programs and efforts to reduce the generation, and improve the management, of solid waste in California in order to conserve resources, develop sustainable recycling markets, to protect public health and safety, and the environment.

Conservation and waste diversion efforts are generally not captured well by environmental indicator systems. Environmental indicators focus on environmental discharges or emissions, ambient environmental conditions, and effects on humans and ecosystems. As such, their emphasis is on the "back end" of industrial society's impacts on the environment. While such information is critical in gauging ecosystem health and identifying broad environmental trends, it tends to de-emphasize the importance of conservation and pollution prevention efforts that are designed to lessen the impacts of human activity on the environment. Inherent in this problem is the fact that the environmental impacts of conservation-based programs are difficult to measure using environmental indicators; rather, these programs are factors that affect natural resources and ambient conditions in the long-term. At present, environmental indicators cannot clearly reflect the effectiveness of some of these programs on ecosystem and human health; however, failing to recognize such programs potentially discounts their tantamount impact on environmental outcomes.

To partially compensate for this, the links below highlight the programs and activities of the California Integrated Waste Management Board and the Department of Conservation (DOC) which lessen pressures on the environment through waste reduction, recycling, and diversion. Although these programs are not "indicators," they are paramount in importance and cannot be ignored when discussing California's environment. Please use the following links to view a listing of conservation and waste prevention programs the state is currently implementing:
www.ciwmb.ca.gov and
www.consrv.ca.gov/dor/index.htm

Issue 1: Material Use

The use of materials requires the consumption of natural resources, and results in waste generation. The manufacture of products from virgin material is generally associated with greater environmental impact than reusing or recycling materials. Certain waste management strategies emphasize waste reduction, as well as the diversion of reusable or recyclable materials from the waste stream.

Characterizing material use in California will provide useful information for formulating waste management strategies. However, such characterization is extremely difficult at this time, given the broad range and massive amounts of products used in businesses, industries and homes.

Issue 2: Waste Generation

Waste generation is the production of material generally intended for disposal. The composition and volume of wastes generated provide an indication of a potential for adverse impacts. Information about the nature of the wastes generated is important in the formulation of strategies to effectively manage it. For example, a recent study shows that paper and organic wastes (food, yard waste, textiles, carpet and rubber) make up about 65 percent of the overall composition of the solid waste stream disposed in California [CIWMB, *Statewide Waste Characterization Study: Results and Final Report*. December 1999. Available at: www.ciwmb.ca.gov/wastechar/study1999/default.htm].

Solid waste generation figures were first estimated in 1989 by each jurisdiction in California, as required by the Integrated Waste Management Act. (Depending on the context used, jurisdiction means a city or county.) Solid waste generation is estimated by adding the amount disposed plus the amount diverted from landfills, as calculated based on guidance issued by CIWMB; the amount diverted reflects source reduction, recycling and composting programs.

Hazardous wastes are regulated under federal law (the Resource Conservation and Recovery Act, or RCRA), as well as under California law (Health and Safety Code, Chapter 6.5), and are tracked by hazardous waste manifests.

The volume of waste requiring management in the state consists of: (a) wastes generated during the course of normal residential, commercial or industrial activity; (b) wastes produced as a result of accidents, spills and releases; (c) wastes generated from cleanup of contaminated sites, and, (d) wastes imported into California.

Sub-issue 2.1: Waste generation, in general

Waste is generated on an ongoing basis. Information about the composition and volume of waste generated can help inform waste management strategies.

Indicators

Statewide solid waste generation per capita (Type I)

Statewide solid waste diversion per capita (Type I)

Hazardous waste shipments (Type I)

Federal and California-only hazardous waste generation

Sub-issue 2.2: Accidents/disasters/spills/releases

Clean-up operations following accidents, disasters (such as earthquakes, floods and fires), spills and other releases generate wastes. Where hazardous chemicals are involved, the resulting waste may be classified as hazardous. In addition, the transportation, storage, treatment and disposal of waste may release environmental contaminants.

Indicator

Hazardous material incidents (Type I)

Sub-Issue 2.3: Waste importation/exportation

The movement of waste to and from California is linked to waste generation and the availability of disposal (or treatment) options at the jurisdiction where the waste was first generated. Waste importation and exportation can also reflect a demand in the receiving jurisdiction for recycling stock or for secondary raw material.

Indicator

Hazardous waste imported/exported (Type II)

Issue 3: Disposal to Land

Disposal is the final placement or destruction of waste. Disposal may be accomplished through placement into a landfill that complies with federal and state requirements, surface impoundments, deep-well injection, or other regulated disposal methods.

Indicators

Statewide solid waste disposal per capita (Type I)

Number of tires diverted from landfills (Type I)

Hazardous waste disposal (Type I)

Issue 4: Site Contamination

Illegal or unsound waste management practices at regulated facilities or unregulated sites can contaminate land, requiring clean-up actions to mitigate threats to human or ecological health. Solid waste sites or dumps, where a responsible party either cannot be identified or is unable or unwilling to pay for timely remediation, are cleaned up under the Solid Waste Disposal Cleanup Program [AB 2136 (Eastin), Chapter 665, Statutes of 1993]. Waste tire sites are of particular concern. When improperly managed, these stockpiles present a significant risk to the environment and public health, due to the potential for fires and the potential to become a breeding ground for insects, especially mosquitoes.

Sites with hazardous material contamination pose a concern due to the potential for human exposure. Contaminated sites include military facilities, "Brownfield" sites (properties that are contaminated or thought to be contaminated which are underutilized due to perceived remediation costs and liability concerns) and legacy sites (sites with historical contamination or naturally occurring hazardous materials, such as asbestos).

Clandestine drug laboratories represent a unique subset of contaminated sites. The predominant illicitly manufactured drug in California is methamphetamine, although other drugs have been manufactured, including PCP (angel dust, phencyclidine), ecstasy, and psilocybin. These labs use a variety of hazardous substances, including acids, bases, and solvents, to synthesize illegal drugs. In addition, many of the products and by-products are toxic and may be extremely toxic. The clandestine labs are sometimes located in residences, thus posing direct risks to occupants and nearby residences. Land, surface water and groundwater contamination may occur as a consequence of the illegal dumping of lab waste. Following the discovery of a clandestine lab by law enforcement agencies, removal of hazardous substances is conducted by DTSC contractors.

Indicators

Clean up of illegal solid waste disposal sites (Type II)

Tire cleanup (Type II)

Soil cleanup (Type I)

Contaminated sites (Type I)

Indicators

Number of environmental releases from active landfills
(Type III)

Groundwater contaminant plumes – Extent
(see Water section)

Contaminant release sites
(see Water section)

Issue 5: Cross-Media Contamination

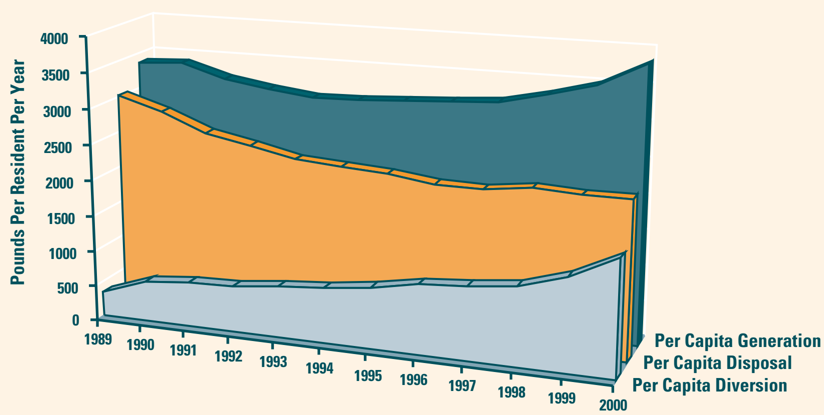
Land disposal of wastes may lead to the movement of contaminants to water or to air, requiring clean-up actions to mitigate potential threats to human or ecological health. Landfill trash generates gases and leachate, sometimes for as long as 200 years. To mitigate cross-media contamination from solid waste landfills, closure and maintenance plans to protect the environment and the public are developed and implemented. Illegal and abandoned dumpsites pose added risks from exposed waste leachate, landfill gas, vectors, and hazardous materials.

Statewide Solid Waste Generation, Disposal and Diversion, Per Capita

Statewide efforts to reduce, re-use, recycle and compost have kept millions of tons of waste out of landfills.

Type I

Level 3
Goal 6



What are the indicators showing?

This graph shows the estimated annual amount of waste generated, disposed, and diverted by each California resident for each year from 1989 through 2000. Per capita disposal of solid waste has decreased, even as generation has increased. This is due to a sharp increase in diversion. Diversion involves recycling, composting and reduction in waste generation.

Why is the indicator important?

Major trends in the production and final disposition of solid waste in California are reflected by this indicator. Thus, it is a valid measure of California's economic sustainability, particularly with respect to resource consumption.

This indicator also measures response to the state's adoption of the Integrated Waste Management Act of 1989 (IWMA). Under the oversight of the California Integrated Waste Management Board (CIWMB), California's cities, counties and businesses have implemented thousands of waste prevention, recycling and composting programs (collectively known as diversion programs).

The waste management hierarchy adopted by the state in the IWMA aims to minimize the rate of solid waste disposal by decreasing the rate of waste generation and by increasing the rate at which waste is diverted from disposal. The IWMA requires all jurisdictions to divert half of their waste in the year 2000; recent legislation extended the 50 percent goal indefinitely. Newspapers and the broadcast media use diversion rates — calculated by removing disposal from estimated generation and expressing the remainder as a percent of total generation — to judge the progress of a particular city or county in reducing waste and complying with the IWMA. The statewide diversion rate has increased from 10 percent in 1989 to 42 percent in 2000.

Disposal measures the solid waste deposited into California's landfills or waste-to-energy facilities, or exported out of the state. Generation measures total waste produced in the state; it is the sum of waste disposed and waste diverted. Diversion measures waste prevented, waste re-used, waste recycled or waste composted.

What factors influence this indicator?

Population growth and economic activity cause waste generation to rise. However, this interdependence can be altered by changes in the character of manufacturing activities, or by waste prevention programs that improve manufacturing processes or packaging methods, and thus slow the growth of waste generation. Public education also impacts this relationship; a decade of efforts by the CIWMB and California's cities and counties to educate the public about waste and recycling issues have raised awareness and changed attitudes about the impacts of consumptive behaviors.

Recycling efforts undertaken by local governments, businesses, citizens and the state determine how much waste will be diverted. Availability of funding influences the extent of these efforts; however, the oversight of the CIWMB, and its ability to levy fines against cities and counties that do not implement waste diversion programs, factor into the number and scope of operating diversion programs. Additionally, the ever-changing composition of the waste stream influences the types of recycling programs that may be effective. Information about programs and activities implemented by the cities, counties and CIWMB can be found at www.ciwmb.ca.gov

The Department of Conservation administers the California Beverage Container Recycling and Litter Reduction Act, enacted in 1986. The goal of the Act is to achieve an 80 percent recycling rate for aluminum, glass, plastic, and bimetal beverage containers sold in California, thereby reducing the beverage container component of litter in the state. Information about this program can be found at: www.consrv.ca.gov/dor/index.htm

Per capita solid waste disposal rates declined dramatically during the early 1990s, as newly implemented diversion programs removed the easiest and most valuable materials from the waste stream. During the boom years of the late 1990s, per capita statewide waste generation climbed. Per capita disposal remained flat during this time of rapid economic growth, most likely due to the efforts of California jurisdictions to implement diversion programs which remove materials from the waste stream.

Continued monitoring of solid waste generation, disposal and diversion will show whether California's cities, counties and state agencies, under guidance from the CIWMB, can meet the challenge of removing the more difficult, and less valuable, resources from the waste stream and channel those to their most appropriate uses.

Technical Considerations:

Data Characteristics

The Integrated Waste Management Act's aim is to conserve resources and extend landfill capacity, not to penalize jurisdictions for increases in population or economic growth. Thus, while having more residents or more economic activity results in increased waste generation, these factors will not automatically cause affected jurisdictions to fail to meet statutory diversion goals. By adjusting waste generation figures for changes in population and economics, the CIWMB-approved "adjustment method" allows year-to-year comparison of a jurisdiction's efforts to reduce disposal, regardless of the changes in population and economics.

Annual waste generation was estimated by all California jurisdictions as part of their original compliance with the IWMA. Since then, waste generation rates for each jurisdiction have been estimated by projecting the original data forward using the aforementioned "adjustment method." CIWMB staff perform a similar calculation to determine statewide estimates.

The CIWMB's Disposal Reporting System (DRS) tracks waste disposal by each city, county and regional agency in California. Tracking originates with each solid waste facility operator, who conducts quarterly "waste origin surveys" to estimate the amount of waste, in tons, disposed at that facility by each jurisdiction. Facility operators report that information to each county, which then submits quarterly disposal reports to the CIWMB. CIWMB staff aggregate that data to produce a statewide total.

The CIWMB calculates the annual 'diversion rate' for each California jurisdiction by subtracting their DRS disposal amount from the waste generation estimated through the use of the adjustment method, and expressing the diversion rate as a percent.

Strengths and Limitations of the Data

Over the years, the CIWMB and its various stakeholders have occasionally disagreed about what constitutes diversion. When diversion studies were performed in the early 1990s, many diversion activities were inadvertently omitted for a number of reasons: because the science and techniques were new; because businesses were reluctant to release what they felt was sensitive waste generation information; because best practices were not known; and because the CIWMB had not yet standardized the measurement process. These early measurements directly impact today's waste generation estimates. Now that measurement techniques have matured, best practices are known, and the CIWMB has improved diversion measurement, accuracy of generation estimates should gradually increase.

Current-year generation estimates for individual jurisdictions may also be impacted by the use of the CIWMB's "adjustment method." Although the CIWMB believes the adjustment method works well for the great majority of jurisdictions, all economic data is not perfectly suited for every jurisdiction. These limitations do not impact statewide data.

Most of the limitations of the diversion measurement system, in particular DRS, concern individual jurisdictions. A good example is the allocation of waste by a landfill to the various cities it serves. Although this localized "allocation" error may tremendously impact a particular jurisdiction, the total waste accepted by the landfill is correct; the latter information is what goes into the statewide disposal figure. Also, because landfill tipping fee taxes are collected by the California Board of Equalization, the CIWMB has a reliable means to check DRS figures.

Ways to improve the limitations of the DRS, the CIWMB-approved adjustment method, and the entire diversion measurement system were considered by a stakeholder working group. The CIWMB will vote on the working group recommendations and forward the report to the Legislature in early 2002.

References:

California Integrated Waste Management Board. *Diversion Study Guide*. Posted at: www.ciwmb.ca.gov/lglibrary/dsg/default.htm

Population totals: Department of Finance, Demographic Research Unit. Posted at: www.dof.ca.gov/HTML/DEMOGRAP/druhpar.htm

Generation totals: California Integrated Waste Management Board. Posted at: www.ciwmb.ca.gov/LGCentral/Rates/Diversion/RateTabl.htm

Disposal and Diversion Statistics: California Integrated Waste Management Board. Posted at: www.ciwmb.ca.gov/LGCentral/Rates/default.htm

For more information, contact:

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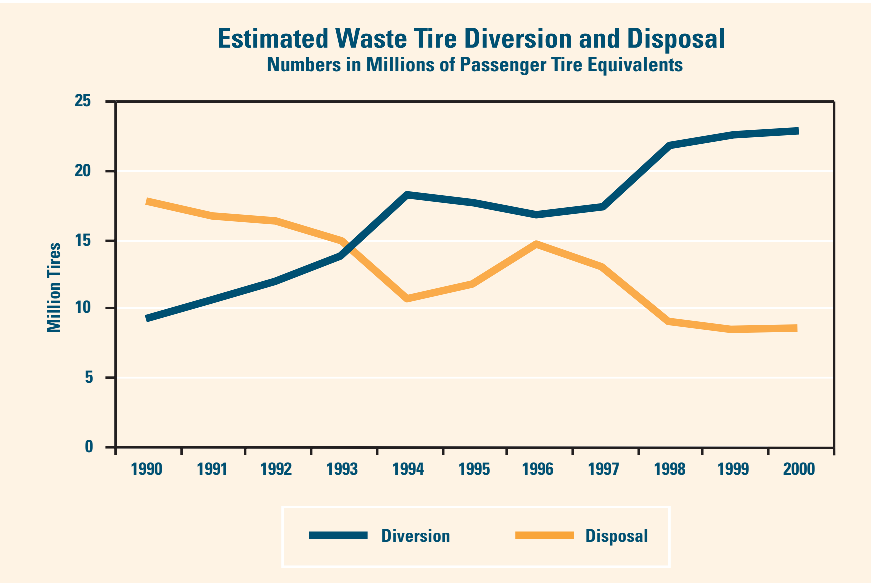
(916) 341-6226
sdhillon@ciwmb.ca.gov

Number of Tires Diverted from Landfills

Significant effors have been made to re-use tires and reduce disposal at landfills.

Type I

Level 3
Goal 6



What is the indicator showing?

Over the past 11 years, the quantity of tires that have been recycled or reused in some manner has increased while those disposed of at landfills has decreased.

Why is this indicator important?

For the year 2000, California was challenged with the responsibly of managing 31.6 million reusable and waste tires entering the waste stream. The California Integrated Waste Management Board (CIWMB) estimates that nearly 23 million tires (72 .5 percent) are diverted annually for various alternative uses, including reuse, re-treading, recycling, and combustion. The remaining 8.7 million tires are shredded and disposed of in California's permitted solid waste landfills, stored at permitted sites, or illegally disposed of around the state. In addition, an estimated two million waste tires are stockpiled throughout the state, posing a health and safety risk to the public.

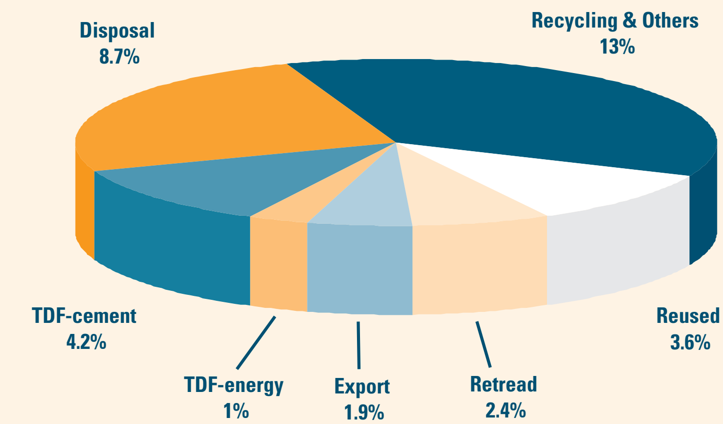
Waste tires are very difficult to deal with. If stored in large quantities, tires can spontaneously combust, emitting highly toxic smoke and particulate matter. Dioxins and polycyclic aromatic hydrocarbons, two highly toxic classes of chemicals, are by-products of tire combustion. As seen in major fires at Westley (1999), Tracy (1998) and Panoche (1996), tire fires can contaminate surface water, groundwater, air, and soil. Tire fires require up to 100 gallons of water per tire to suppress, creating additional environmental problems. Often the best course of action for firefighters, as in Tracy, is to let the fire burn itself out, which can take months.

Since water collects in tires, they can also serve as breeding grounds for mosquitoes that, in addition to being a nuisance, can carry serious diseases such as encephalitis. Encephalitis can be a very serious, even fatal, disease in children. Livestock is also seriously affected by a number of strains of encephalitis. For these reasons, proper disposal of tires is of great significance.

What factors influence this indicator?

The main factor influencing the ability to divert tires from landfills or illegal dumping is the development of viable markets for waste tires. Tires can be burned as fuel supplement at cement kilns. They can be incorporated into asphalt used in road construction. Tires can be decomposed into three recoverable fractions — carbon black (with steel, fiber and ash), oil and gas – through a process known as pyrolysis; also known as gasification, liquefaction, or destructive distillation, pyrolysis is defined as thermal degradation in the absence of oxygen. The development of alternative uses for tires is linked to economic development and profitability, which at present is still weak. The chart below illustrates the fate of waste tires based on estimates for the year 2000. As a note, "Passenger Tire Equivalents" is a measure based on a 20-pound average weight of a passenger car waste tire. This conversion factor allows for a common unit of measure since waste tires come in many different sizes.

Estimated Reusable and Waste Tire Recycling & Disposal 2000
(Numbers in Millions of Passenger Tire Equivalents)



TDF = Tire-derived Fuel

The use of waste tires for energy and as a fuel supplement in cement kilns, and the import and export of waste tires are significant factors reflected in the diversion and disposal trends shown on the graph for this indicator. Diversion of waste tires from landfill disposal has largely increased since 1990, with a sudden increase in 1994. This increase coincided with increases in the number of waste tires combusted for energy and as a fuel supplement in cement kilns. Until 1994, a major combustion facility largely burned newly generated waste tires (i.e., tires generated during the same year). As a result of legal action, however, the facility was directed to burn decades-old tires from a tire pile. Waste tire disposal has generally decreased during the past decade, except for a peak in 1996, when the number of imported waste tires more than doubled, as their use in energy production and cement kilns declined.

In FY 1999/2000, the Board awarded $2.4 million in grants and contracts to 78 businesses and government entities through its waste tire diversion program. Of the total funding, 15 percent ($374,043) was directed to public education outreach and amnesty day programs implemented at the local level to prevent illegal disposal. Schools and local governments received 42 percent ($1,012,918) for the installation of rubber playground mats and track surfacing projects promoting the use of tire-derived crumb rubber. Twelve percent ($299,990) was used to promote the commercialization of emerging technologies for recycling tires. Thirty-one percent of the funds ($755,000) supported rubberized asphalt concrete (RAC) projects. One grant ($7,500) supported the purchase of tire-derived green building products.

Amount	% of total	Type of project
$374,043	15.3%	Public education outreach, “amnesty day” programs (local jurisdictions)
$1,012,918	41.4%	Rubber playground mats and surfacing projects promoting the use of tire-derived crumb rubber (in schools, local government)
$299,990	12.2%	Commercialization of emerging recycling technologies
$755,000	30.8%	Rubberized asphalt concrete projects
$7,500	0.3%	Tire-derived green building products

In addition to the development of new markets for waste tires, legal restrictions have impacted tire disposal. In 1990, the California Legislature enacted comprehensive requirements for the storage and disposal of waste tires. Assembly Bill (AB) 1843 created an environmental regulatory program to control the storage and disposal of waste tires. AB 1843 requires persons who store or stockpile more than 500 waste tires at a specific location to acquire a major or minor waste tire facility (WTF) permit and comply with technical standards for the safe storage of waste tires. By definition, a major WTF stores, stockpiles, accumulates, or discards 5,000 or more waste tires; a minor WTF stores between 500 and 5,000 waste tires. In 2000, Senate Bill 876 was signed into law, increasing the fee on the sale of new tires and extending the CIWMB’s regulatory authority.

Technical Considerations:

Data Characteristics

Currently, there is no mandated reporting requirement to report waste tire uses to the state. The generation estimates discussed are based on population; the number of vehicles registered in the state; vehicle miles traveled; and average fuel consumption. Reuse/recycling numbers are based on information from businesses involved with waste tire collection and processing.

Strengths and Limitations of the Data

The indicator is based on estimated, rather than collected data. However, a revised manifest system is being developed; which should solve the problem of determining the number of waste tires generated in the state, as well as the number of tires reused and recycled.

References:

Tire Management Data: California Integrated Waste Management Board. Posted at. www.ciwmb.ca.gov/Tires/default.htm

California Integrated Waste Management Board. *Waste Tire Management Program: 2000 Annual Report.* July 2001. Posted at: www.ciwmb.ca.gov/Publications/default.asp?pubid=910

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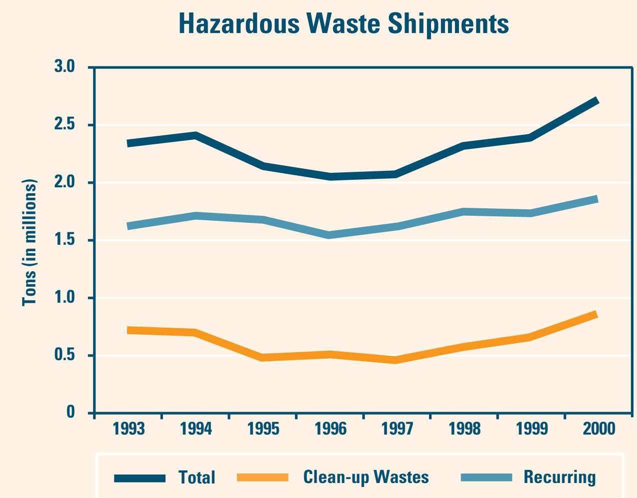
Type I

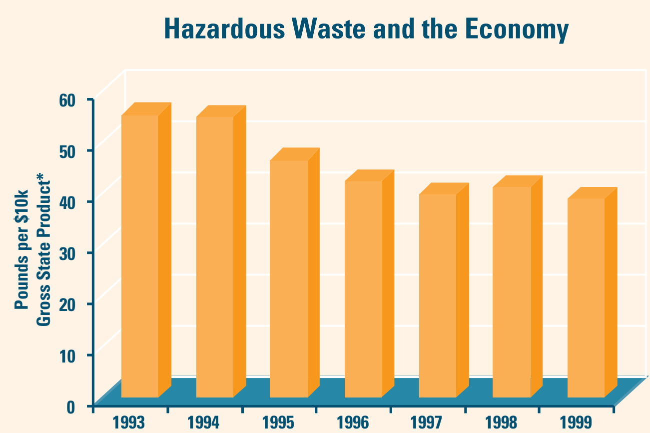
Level 3
Goal 6

Hazardous Waste Shipment

More hazardous waste is being shipped, but less per unit of economic activity.



Note: Cleanup wastes include PCB-contaminated wastes, asbestos, and soil from site cleanups.



*GSP in current dollars

What is this indicator showing?

The amount of hazardous waste shipped has been increasing since 1996. The total amount consists of clean-up wastes and recurring wastes. The amount of these cleanup wastes has increased by almost 20 percent since 1996, while recurring wastes increased by only 15 percent during the same time period. Over the past seven years, the amount of hazardous waste generated per unit of economic activity has decreased; 30 percent less waste was generated per $10,000 of gross state product in 1999 than in 1993.

Why is this indicator important?

This indicator reflects the annual amount of hazardous waste generated in California, and subsequently shipped for treatment, storage and disposal; it does not include hazardous waste which has been treated or disposed onsite (at the facility where it was generated). Total hazardous waste tonnage is separated into “cleanup wastes” and “recurring wastes.” “Clean-up wastes” include those containing polychlorinated biphenyls (PCBs) or asbestos, and those generated following site cleanups; the removal of these wastes from the environment for treatment or disposal in a secure landfill reduces the potential for exposures to their hazardous constituents. “Recurring hazardous wastes” are generated in the course of commercial or industrial operations.

Unless managed in an environmentally sound manner, hazardous wastes can cause adverse impacts on human and ecological health. The transportation, storage, treatment and disposal of hazardous waste create a potential for the release of hazardous chemicals into the environment. Pollution prevention activities can reduce the quantity and composition of hazardous waste generated.

What factors influence this indicator?

The total amount shipped annually is presented as the overall statewide trend. Since 1993, the amount of waste shipped has increased by approximately 16 percent. Because hazardous waste generation is related to economic activity, the amount generated per $10,000 of Gross State Product (GSP) is also presented. A different trend is revealed — one which shows a consistent decline. This means that the state's economy is producing less hazardous waste per unit of economic activity.

Certain sectors of the economy, most notably the manufacturing sector, are likely to produce more hazardous waste than others. California's economy has shifted over the past two decades to one which is increasingly becoming services-oriented (the services sector of the economy includes business services, health services, hotels and lodging, repair services, and others).

Cleanup activities, which include asbestos removal from homes and businesses and removal of contaminated soil, will affect the amount of hazardous waste shipments, as will changes in California's classification of wastes as hazardous. As more wastes (e.g., cathode ray tubes and other electronic wastes) are properly managed as hazardous waste, the amount of hazardous waste shipments will also increase.

In the past decade, environmental programs have emphasized the need for pollution prevention efforts instead of the more traditional "end-of-pipe" remedies. In California, the Department of Toxic Substances Control (DTSC) has been responsible for the implementation of legislation to promote source reduction. The trends in hazardous waste generation will obviously be impacted by the number of businesses that carry out source reduction plans and strategies. The amount of hazardous waste per small generator has been decreasing since 1993 (DTSC, 2000).

Other factors that influence hazardous waste generation trends include: the availability and accessibility of cleaner technologies; the intensity of local programs which could bring more businesses into the hazardous waste regulatory framework; the availability of options (or lack of capacity) for hazardous waste treatment and disposal; the costs of treatment and disposal; and improved compliance with, or enforcement of, hazardous waste requirements.

Technical Considerations:

Data Characteristics

Data for the indicator are based on amounts reported on hazardous waste manifests. The generator of the waste is required by law to prepare a manifest for every offsite shipment of hazardous waste. Manifests include information on the generator, transporter and treatment, storage or disposal facility receiving the waste, and the type and quantity of the waste shipment. The manifests are designed to track each shipment from "cradle to grave," that is, from the site of its generation to the facility designated by the generator. Once the shipment reaches its destination, the manifest is returned to the DTSC, where data from the form are entered into an automated data system known as Haznet.

The data include waste from site cleanups, which reduce human and ecological risk, and from household hazardous waste collection centers.

The Gross State Product data are maintained by the U.S. Department of Commerce, Bureau of Economic Analysis.

Strengths and Limitations of the Data

These data include wastes regulated as hazardous under the federal law known as the Resource Conservation and Recovery Act, or RCRA, as well as hazardous waste as defined by the State of California in Title 22, California Code of Regulations (also known as "non-RCRA waste" or "California only hazardous waste"). Because non-RCRA wastes are included, the indicator is not comparable with other states or nationally.

As noted earlier, data on hazardous waste treated onsite are not included. On the other hand, there is a potential for accounting for certain shipments, such as those to transfer stations, more than once. An additional limitation is associated with converting the units reported on the hazardous waste manifest to a consistent measure of weight; conversion factors may not adequately account for the variance in density of the range of wastes shipped. Finally, generators of the hazardous waste must enter on the manifest the appropriate California Waste Codes for the waste material being shipped. Because of the nature of this coding system, differentiating the type of material, or distinguishing between one-time and recurring wastes cannot be easily done.

Because manifests are required for all offsite shipments of hazardous waste, the data are considered quite complete.

References:

Hazardous waste tonnage: Department of Toxic Substances Control, Haznet data system.

Gross State Product: U.S. Department of Commerce, Bureau of Economic Analysis: Posted at: www.bea.doc.gov/bea/regional/gsp/

Department of Toxic Substances Control. *Pollution Prevention Report and 2-Year Workplan.* Office of Pollution Prevention and Technology Development, September, 2000. Posted at: www.dtsc.ca.gov/PollutionPrevention/pp-report-and-2year-workplan.pdf

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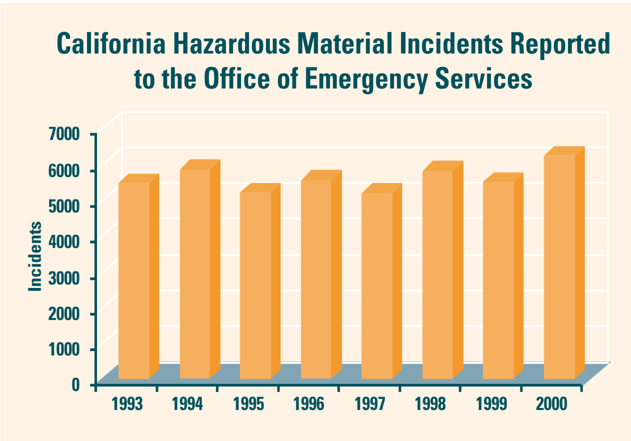
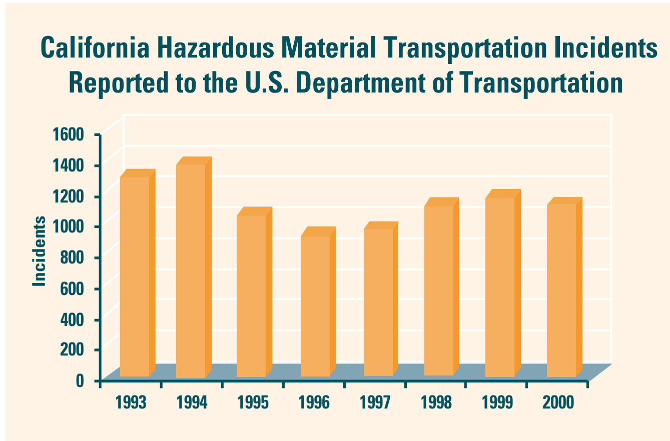
Hazardous Material Incidents

The number of hazardous material incidents has been relatively consistent.

Type I

Level 3
Goal 6





Why is this indicator important?

Releases, spills, or other incidents involving hazardous materials pose an immediate and direct threat to humans and the environment. The first indicator shows the number of incidents involving hazardous materials that have been reported annually to the Governor's Office of Emergency Services (OES). The U.S. Department of Transportation (DOT) collects standardized, detailed reports of hazardous material transportation incidents nationwide; the second indicator tracks the incidents that were reported in California. Transportation-related hazardous material incidents represent a subset of all hazardous material incidents. Hazardous waste shipments, a separate indicator, are a small subset of hazardous materials shipments in California.

Hazardous material incidents represent potential pressures on human health and the environment exerted by accidental releases of hazardous materials. In many cases, cleanup operations following these incidents generate waste that may be classified as hazardous wastes. Tracking these incidents over time can help guide the formulation of policies or strategies to prevent the occurrence of future incidents, or to improve responses to minimize the adverse impacts of these incidents.

What factors influence this indicator?

Most hazardous material incidents represent accidental releases — that is, the release is a consequence of an unplanned and unintended event or series of events. The occurrence of accidents can generally be minimized by good operating practices, including the use of appropriate, well-maintained equipment, operated by properly trained employees. In many cases, regulatory

What is the indicator showing?

Over the past seven years, the number of incidents involving hazardous materials reported to the Office of Emergency Services has remained relatively constant; the highest number was reported in 2000. During the same time period, incidents involving the transportation of hazardous materials have fluctuated between 800 and 1,400 per year.

requirements or industry standards have been promulgated to ensure the safety of processes and equipment. Hence, various operational and equipment factors can influence the frequency of hazardous material incidents.

The likelihood of the occurrence of a release also increases with the amount of the material being handled or transported. Economic factors can directly influence manufacturing and shipping activities. One would expect the increased amount of materials used and transported to result in increased spill and transportation incidents. Improved storage, treatment, and transportation technologies and enforcement capabilities may contribute to a decrease in the number of incidents.

It is difficult, however, to draw conclusions regarding the specific factors that influence the trends shown by the indicators. Overall, the number of hazardous material incidents remained relatively constant, with the highest number of incidents being reported in 2000. Incidents involving the transportation of hazardous materials have fluctuated over the past seven years. The fluctuations, however, have occurred over a relatively narrow range (from approximately 900 incidents in 1996 to approximately 1,400 in 1994).

Technical Considerations:

Data Characteristics

The data for hazardous material incidents are from the Governor's OES. State law requires all significant releases or threatened releases of hazardous material, including oil, be immediately reported by telephone to the OES' Warning Center. These reports are received from handlers, employees, authorized representatives, agents or designees of handlers. State notification requirements for a spill or threatened release include the caller identity; location, date and time of spill, release or threatened release; chemical name and, quantity involved; and description of the event.

The data for transportation-related incidents are part of the Hazardous Materials Information System (HMIS), which is maintained by the DOT, Office of Hazardous Materials Safety. The data are provided by hazardous materials shippers or transporters, who complete a Hazardous Materials Incident Report, and submit it to the DOT Office of Hazardous Materials Transportation.

Strengths and Limitations of the Data

Calls made to the OES Warning Center are not verified, and may include reports that did not actually involve hazardous materials. All calls are counted as incidents, regardless of the extent of threat to public health and the environment. Because the data depend on reports from handlers and other involved parties, the threat of liability may hinder reporting.

Incidents that are subject to the reporting requirement to U.S. DOT are those involving hazardous materials, as defined in Title 49 of the Code of Federal Regulations. Materials which do not meet the DOT definition may still pose a risk to public health or the environment and not be captured by these data. For example, the 1991 metam sodium spill into the Sacramento River following a train derailment would not have been captured as a hazardous material incident; at the time of the spill, metam sodium was not regulated by DOT as a hazardous material.

Finally, the indicator presents a crude measure of an environmental pressure. The impacts of the incidents on humans and the environment cannot be determined from an aggregate count of a wide range of incidents.

References:

Governor's Office of Emergency Services, Hazardous Materials Spill Database.

U.S. Department of Transportation, *Biennial Reports on Hazardous Materials Transportation.* Office of Hazardous Materials Safety, Research and Special Programs Administration. Posted at hazmat.dot.gov/ohmforms.htm#biennial

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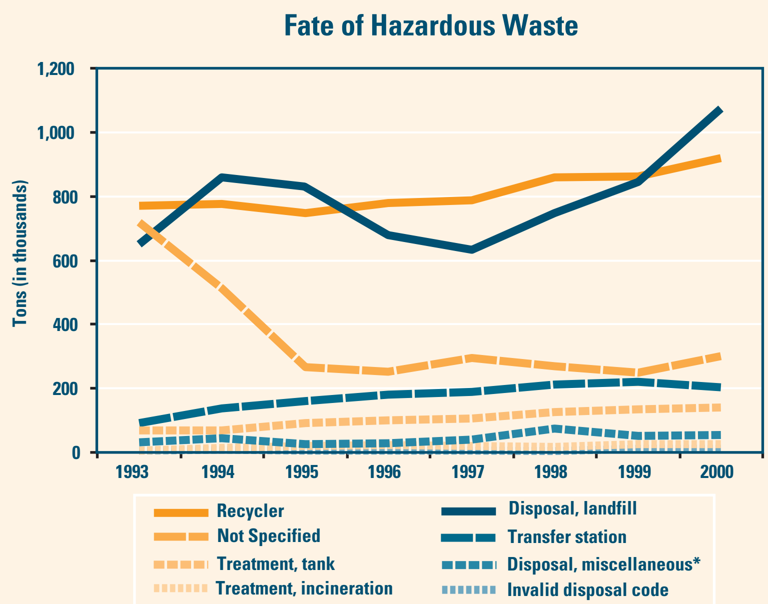
Type I

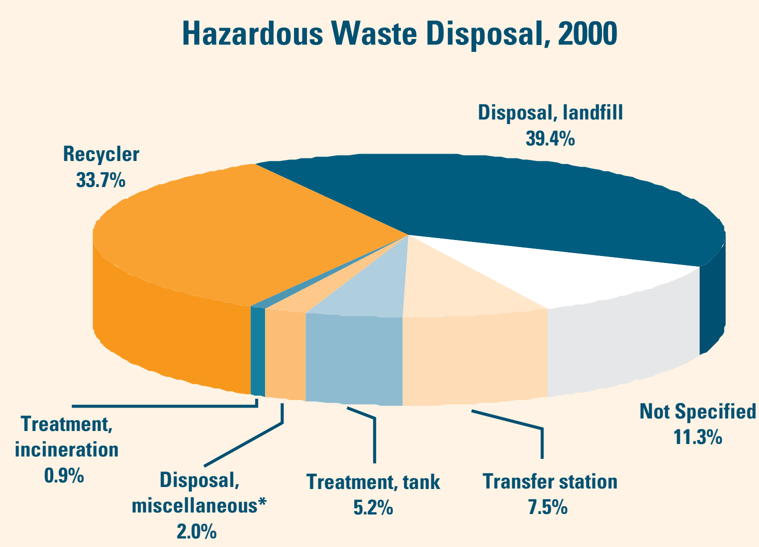
Level 3
Goal 6

Hazardous Waste Disposal

Most hazardous waste shipped offsite is landfilled or recycled.



*Disposal, miscellaneous includes surface impoundment, land application, injection well, other



*Disposal, miscellaneous includes surface impoundment, land application, injection well, other

What is the indicator showing?

Almost three-quarters of the hazardous waste shipped offsite in 2000 was destined for disposal in landfills or recycling. In recent years, more hazardous waste is being sent to recyclers (about a 19 percent increase since 1993), but even more waste is going to permitted landfills (a 65 percent increase during the same time period).

Why is this indicator important?

The indicator shows trends in how hazardous wastes are managed, based on information from manifests prepared for each shipment of hazardous wastes. The various methods used to treat and dispose of hazardous wastes each have a potential associated risk. The ultimate fate of hazardous waste reflects potential pressures on human health and the environment.

Disposal in landfills has fluctuated over the past seven years, but has been on the increase in recent years. In 2000, more of the hazardous wastes ended up in landfills than in other destinations. Over 25 percent more tons were disposed in landfills that year than in the previous year; over the past seven years, there has been a 65 percent increase in the amount disposed in landfills. Although today's permitted landfills are designed to prevent the movement of hazardous constituents into water, air, or other media, the possibility of environmental contamination still exists. Further, landfill disposal uses up valuable land resources.

Recycling is the second most prevalent method for managing hazardous wastes in 2000. The trend in recycling hazardous waste is relatively stable, but is on a slight increase (a 20 percent increase since 1993, and about an 8 percent increase over the previous year). By recovering and reprocessing usable chemicals from wastes, recycling reduces the volume of waste destined for disposal, and reduces the need to extract and/or process virgin material.

Over six percent of the hazardous waste in 2000 was destined for treatment facilities. Treatment involves changing the physical, chemical, or biological character or composition of a hazardous waste, or removing or reducing its harmful properties or characteristics. Treatment methods include incineration (which can create hazardous byproducts), tank treatment, and surface impoundment. Other disposal methods include land application, surface impoundments, injections wells and others. Amounts that are destined for transfer stations are also tracked. However, because wastes are generally shipped to transfer stations for temporary storage or consolidation, these facilities are only an interim recipient of hazardous wastes.

The "Not Specified" category – which makes up over ten percent of the wastes in 2000 — includes California-only hazardous waste shipped out of state, as well as manifests with no disposal code identified. The tonnages for this category have declined significantly (by almost sixty percent) since 1993.

What factors influence this indicator?

Disposal and treatment options selected by hazardous waste generators can be influenced by existing regulations and policies governing hazardous waste management, by the availability and accessibility of disposal and treatment facilities, and by the costs associated with the various options. For example, policies that provide incentives for, or otherwise encourage, alternatives to disposal would tend to decrease the proportion of wastes being disposed of in landfills. Restrictions on the types of wastes that can be disposed of in landfills, imposed either by regulation or by the landfill operator, will also tend to impact the trends.

The characteristics of the waste is another factor. Some types of hazardous wastes, such as waste solvents, or wastes containing recoverable metals, will likely be shipped for recycling rather than for disposal. Some hazardous wastes, such as polychlorinated biphenyls (PCBs), can only be incinerated.

Site cleanups can generate large amounts of contaminated soil. These are typically disposed of in landfills, or shipped out of state. Hence, increased cleanup activities or the cleanups which involve the removal of large volumes of contaminated soil can increase the proportion of wastes destined for landfills or in the “Not Specified” category.

Technical Considerations:

Data Characteristics

Data for this indicator are based on information reported on hazardous waste manifests. The generator of the waste is required by law to prepare a manifest for every offsite shipment of hazardous waste. Manifests include information on the generator, transporter and treatment, storage or disposal facility receiving the waste; and the type and quantity of the waste shipment. The manifest is designed to track each shipment from “cradle-to-grave,” that is, from the site of its generation to the facility designated by the generator. Once the shipment reaches its destination, the manifest is returned to the Department of Toxic Substances Control, where data from the form is entered into an automated data system known as Haznet.

Strengths and Limitations of the Data

The indicator presents data on the management of hazardous waste defined by the State of California (Title 22, California Code of Regulations), also known as non-Resource Conservation and Recovery Act (RCRA) hazardous waste, and by the federal government under RCRA (Title 40, Code of Federal Regulations). Manifests are required for all hazardous waste generation, so the data are considered quite complete. Because this includes non-RCRA as well as RCRA waste, the numbers are not comparable with other states, which only track RCRA waste.

The generator of the hazardous waste is responsible for entering appropriate information on the facility designated to receive the shipment. In some cases, this information is not provided. The “Not Specified” category includes data from manifests which had a blank destination, and includes non-RCRA hazardous waste shipped out of state, where it is not tracked as a hazardous waste.

Reference:

Department of Toxic Substances Control Haznet data system.

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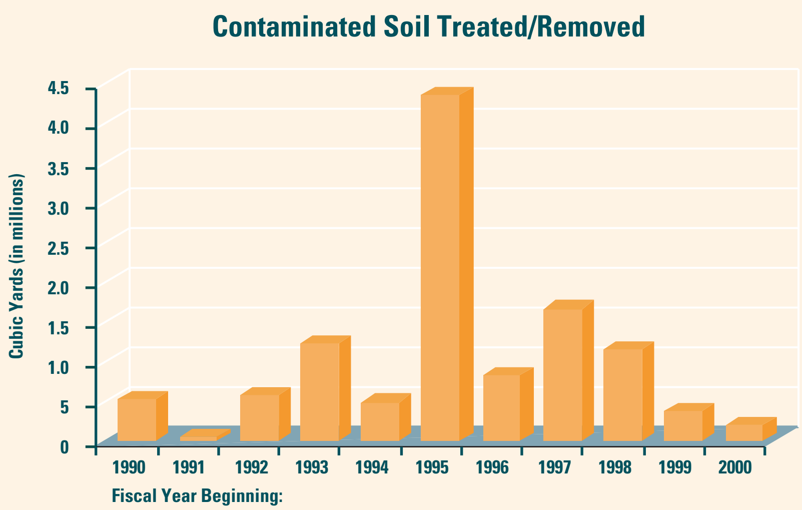
Soil Cleanup

During the 1990's, over eleven million yards of contaminated soil and other solids were treated or removed from sites.



Why is this indicator important?

Contaminated soil poses a threat to human and ecological health. Treatment of contaminated soil reduces this threat by eliminating potential exposures to humans, animals, and the environment. Adverse effects on the health of humans, animals and plants can result from direct contact with contaminated soil. Also, soil can provide a source or "reservoir" for contaminants, since chemicals have the capacity to migrate from soil to other environmental media, such as air and water. Such movement to other media increases the likelihood of exposure to hazardous waste constituents. The ultimate goal of site cleanup efforts is to allow the appropriate reuse of previously contaminated sites. The feasibility of presenting a measure of the land area restored for use following cleanup will be explored.

What factors influence this indicator?

Soil cleanup is the end-point of a lengthy regulatory process that generally takes years to complete. The process begins with a remedial investigation and feasibility study, which includes an assessment of the site history, development of a sampling plan, sampling and analysis of environmental media, human health and ecological risk assessments, and developing a feasibility study and remedial action plan. Typically, each of these steps involves public involvement and input; regulatory agencies are required to respond to public concerns by holding community meetings and preparing fact sheets for the affected community. The rate of removal of contaminated soil may be influenced by any of the steps in this process.

Type I

Level 3
Goal 4, 6

What is the indicator showing?

The indicator tracks the volume of contaminated soil and other solids cleaned up at hazardous waste sites. Soil volumes have fluctuated over the past decade. (Note: Data were not routinely entered into the CalSites database until fiscal year 1996/97).

Treatment of contaminated soil may be influenced by the availability of resources, both within the regulatory agency having jurisdiction over the contaminated site, as well as the party responsible for cleanup. In some cases, removal and/or treatment may not be perceived by the responsible parties as being in their best interests. Costs arising from maintenance (restricting access, monitoring contaminant levels, etc.) are relatively low, but removing and/or treating contaminated soil frequently requires a large expenditure of capital.

Prevailing policies and available technology may also influence soil cleanup. For example, "natural attenuation" (i.e., allowing hazardous constituents to degrade to non-hazardous chemicals without intervention) became a viable response to cleanup of contaminated sites following publication of a scientific report on the behavior of petroleum contamination. This resulted in the adoption of remediation policy for petroleum contamination that reduced the emphasis on removal of contaminants, shifting the emphasis instead on long-term monitoring. The treatability of the contaminants and the availability (and affordability) of technology for treatment are also significant factors.

Additionally, certain characteristics of the contaminated site, such as the location of contaminants in inaccessible areas (soil beneath buildings, water mains, or power lines), may make treatment extremely costly or technically infeasible.

Technical Considerations:

Data Characteristics

The data were compiled from the Department of Toxic Substances Control's (DTSC) CalSites database, now called the Site Mitigation Program Property Database. The database contains information on sites in California where hazardous substances have been released, or where the potential for a release exists. The data were not routinely entered into CalSites until fiscal year 1996/97, when extensive revision of the database was completed. Data for prior years are less reliable.

The data used for the indicator are for the total volume of "solid hazardous substances" from contaminated sites removed and/or treated; these generally consist mostly of contaminated soil. The data are recorded for the fiscal year (July 1 through June 30 of the following calendar year) during which the removal action, expedited response action, interim remedial action, final remedial action, or certification action was completed.

Data for liquid wastes treated or removed from contaminated sites are not presented.

Strengths and Limitations of the Data

The data only reflect cleanup actions under DTSC's oversight. Other state agencies, particularly the Regional Water Quality Control Boards, are also responsible for the oversight of removal and/or treatment of contaminated soil. The data do not reflect actions initiated by other state or local agencies.

As an environmental indicator, the volume of soil removed and/or treated is an incomplete measure of the reduction in risk to human health and the environment, because it does not reflect the location, concentration or toxicity of the contaminants that are removed. Clearly, the removal or treatment of soil contaminated with low concentrations of less toxic contaminants from a remote area would represent a relatively small reduction in risk in comparison to removal or treatment of soil contaminated with high concentrations of very toxic contaminants from an area immediately adjacent to human populations or animal or plant habitat.

Reference:
Department of Toxic Substances Control, CalSites Database

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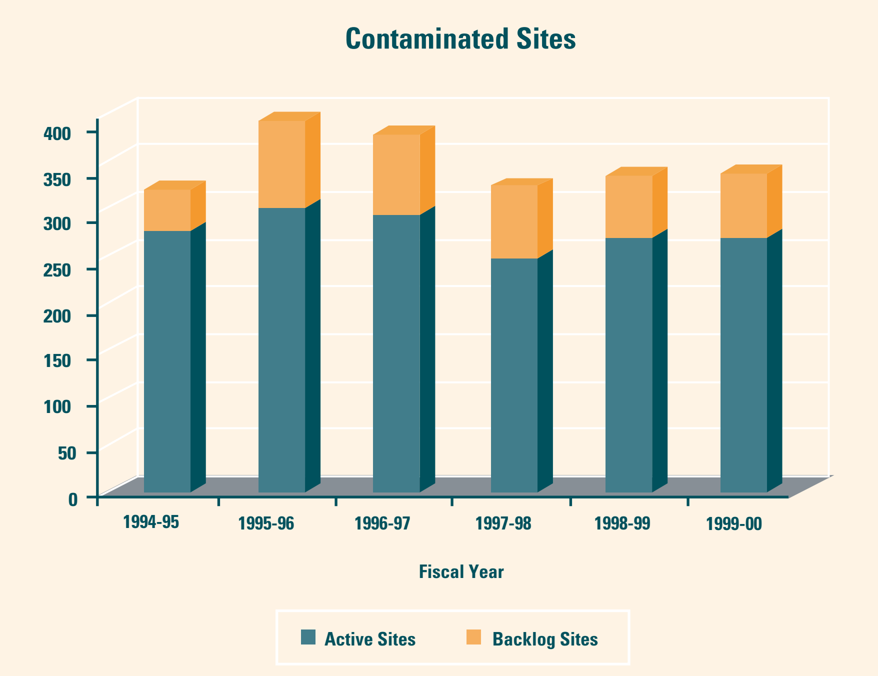
Type I
Level 3
Goal 4, 6

Contaminated Sites

Since 1994, there have been 300 to 400 active annual workplan and backlog sites in California.



What is this indicator showing?

The number of contaminated sites has remained relatively stable, with "backlog" sites making up about 25 to 30 percent of all sites. Backlog sites are those not currently being investigated or remediated by the Department of Toxic Substances Control.

Why is this indicator important?

The indicator tracks the number of contaminated sites, including military facilities, legacy sites (sites with historical contamination or naturally occurring hazardous materials, such as asbestos), and sites on the federal National Priority, or "Superfund" List. Contaminated sites at currently permitted facilities are not included. An "active" site is a property having a confirmed release of hazardous substances that the Department of Toxic Substances Control (DTSC) is actively working to remediate. Active sites generally are high priority, high potential risk sites. A "backlogged" site is a property having a confirmed release of hazardous substances that DTSC is not currently investigating or remediating.

Contaminants in soil or other media pose a risk to human health and the environment (ecological receptors) should direct contact occur. Evaluating and managing contaminated sites with the ultimate objective of removing the contaminants will eliminate the possibility of exposure to the contaminants, thereby eliminating the risks.

Over time, contaminants can migrate from the original source areas to adjacent properties or to other environmental media, such as air and water. Leaching of contaminants from soil to groundwater is a particular concern if the groundwater serves as a source of drinking water or is used for agriculture. If contaminated properties are not remediated, the scope and magnitude of the environmental problem may increase. The extent that contaminated sites that are either mitigated or treated reduces the threat of contaminant migration and reduces the possibility of harmful public health effects.

What factors influence this indicator?

Site contamination can result from hazardous materials and hazardous waste management practices carried out at a facility. The indicator is influenced by DTSC's capacity and resources to identify and manage hazardous waste sites. The number of sites tracked by the indicator is a subset of the universe of all contaminated sites in the state. A more comprehensive accounting of contaminated sites — which will include those that are under the oversight of regional water boards or local agencies — will be provided in future reports.

This indicator does not reflect the complexity of individual sites. Large industrial and military sites can be complex and can require many years to evaluate and remediate. It is not uncommon for these sites to be "carried over" from one year to the next. Consequently, larger, more complex sites may absorb a relatively large proportion of staff resources. In contrast, smaller, less complex sites may simply require a Preliminary Endangerment Assessment and little or no remediation. Smaller sites often require considerably less staff time, and their certification as clean may not reflect a significant reduction in risk to human health and the environment.

Hazardous waste sites that are on the Superfund List are also tracked by this indicator. There are currently 96 Superfund sites listed in California, three sites proposed for listing, and five sites deleted from the National Priority List. A listing of these sites can be found at the U.S. EPA Web site, www.epa.gov/superfund/sites/npl/ca.htm

Technical Considerations:

Data Characteristics

The data were compiled from the CalSites database, which includes sites such as military facilities, "Brownfield" sites and legacy sites. Active sites are those which are listed pursuant to Health and Safety Code 25356, and are known as State Superfund or annual workplan sites. Sites are removed from this list after all remedial actions have been completed and the site has been certified by DTSC. Backlogged sites are those sites that DTSC is not actively investigating or remediating. However, before a site is backlogged, DTSC ensures that the site does not pose immediate hazards to the public or the environment. Data are given for state fiscal years, which run from July 1 to June 30.

The data were not routinely collected prior to fiscal year 1993/94.

Strengths and Limitations of the Data

The data do not include hazardous waste treatment, storage and disposal facilities. Environmental contamination at these properties is addressed under the RCRA (Resource Conservation and Recovery Act) corrective action program. The data also do not reflect sites being investigated and/or remediated by other state agencies, such as the Regional Water Quality Control Boards or local agencies.

As noted above, the data do not provide a direct indicator of risk reduction, since complex sites, with relatively high concentrations of contaminants, and simple sites, with much lower levels, are counted equally.

These data do not show the extent of contamination, so the data do not directly show the reduction in risk to humans or the environment. Separate data is not currently available for federal National Priority List sites.

Reference:
Department of Toxic Substances Control, CalSites data base.

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Federal and California-only hazardous waste generation

Type II

Total hazardous waste is presented as a Type I indicator. However, hazardous wastes regulated in California fall under two types: (1) hazardous waste regulated under federal law, known as the Resource Conservation and Recovery Act (RCRA); these are commonly referred to as "RCRA hazardous wastes"; and (2) hazardous waste as defined by regulations promulgated under the authority of California's Hazardous Waste Control Act; these are commonly known as "non-RCRA" or "California-only" hazardous wastes (although the latter is a misnomer, since some non-RCRA hazardous wastes may also be regulated as hazardous waste in some other states).

All RCRA hazardous wastes are also regulated as such in California. However, because of the broader scope of California's regulation, additional wastes are identified as hazardous in California. Under both RCRA and California law, a waste is designated as hazardous if it is ignitable, reactive, corrosive, or toxic. California's criteria for corrosivity and toxicity are broader than the federal criteria. For example, the toxicity criterion is applied using a list that includes substances not on the RCRA list, and California's Waste Extraction Test is more stringent than the federal extraction test. California law also regulates some wastes exempted under federal regulations.

Tracking RCRA and non-RCRA hazardous waste separately would allow comparison of California data with those of other states, and would enable aggregation of data for regional or national tracking. The current database for hazardous waste tracking, Haznet, cannot easily separate non-RCRA hazardous waste from federally regulated RCRA hazardous waste.

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Hazardous waste imported/exported

Type II

Total hazardous waste generated in California is presented as a Type I indicator. The current hazardous waste tracking system does not allow for the tracking of imports of hazardous waste and exports out of the state. One reason is the different universe of hazardous waste in California compared to other states. California-only (non-RCRA) hazardous waste is no longer hazardous waste when shipped out of California. As a result, the manifest tracking system does not track exported waste from "cradle-to- grave," since the ultimate receiver of the waste is not required to complete the manifest information.

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Type II

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Cleanup of illegal solid waste disposal sites

The indicator will track the cleanup of illegal solid waste disposal sites where the responsible party either cannot be identified or is unable or unwilling to pay for the timely remediation, and where clean up is needed to protect public health and safety or the environment.

Currently, the tracking system for solid waste sites cleaned up is not available as a database. The Remediation, Closure, and Technical Services Branch of the Permitting and Enforcement Division of the California Integrated Waste Management Board does have information on the amount of illegally disposed of solid waste sites cleaned up, such as, location, type/volume of wastes removed, and site cleanup cost.

Type II

Tire cleanup

It has been estimated that 31 million tires are generated each year in California. While representing only about one-half of one percent by weight of the total municipal solid waste stream, tires present an unusual disposal problem because of the special handling and processing needed to properly dispose of them.

As a result, California has between two and three million waste tires illegally dumped or stockpiled. These stockpiles pose potential threats to the public health, safety, and environment, particularly when they are improperly maintained or when they catch on fire. Uncontrolled open tire burning generates toxic smoke and other by-products such as pyrolytic oil and ash that may contaminate the air, soil, groundwater, and surface water. The intense heat leads to the generation of pyrolytic oil that mixes with extinguishing material, contaminating surrounding soils, surface waters, and groundwater (one tire can produce up to two gallons of oil).

Pursuant to Public Resources Code (PRC) §42826, the California Integrated Waste Management Board (CIWMB) may perform any cleanup, abatement, or remedial work required to prevent substantial pollution, nuisance, or injury to the public's health and safety at waste tire sites where the responsible parties have failed to take appropriate action as directed by the CIWMB. In general, these waste tire sites are referred to the Waste Tire Stabilization and Abatement (WTSA) Program once CIWMB's Waste Tire Enforcement Program has exhausted enforcement efforts. Typical remedial efforts conducted under the WTSA Program may entail stabilizing piles until they can be removed, removal of all waste tires, removal of contaminated debris and remediation of the site after removal of the tires.

To date, the CIWMB has awarded four contracts totaling approximately $8.1 million. Since 1995, CIWMB has removed more than 11.2 million illegal waste tires from 44 sites, at an average removal cost of $0.61 per tire, for a total cost of nearly $6.9 million.

YEAR	Number of Sites	Remediation Cost	Total Number of Tires Removed	Average Cost Per Tire
1995	6	$870,832	2,154,400	$.40
1996	6	$389,487	411,436	$.95
1997	9	$1,367,760	2,832,916	$.48
1998	7	$2,726,196	4,488,325	$.61
1999	15	$1,568,905	1,334,500	$1.18
2000	6	$1,690,505	1,920,500	$0.88
Totals	49	$8,276,864	12,862,380	$0.64

Remediating existing tire piles is a challenge. The costs associated with remediation are considerable, and property owners and operators are many times reluctant to expend the money for major cleanup operations. Compounding the problem is the fact that many tire piles are located on economically undesirable land where cleanup costs exceed the value of the land itself, making land seizure a hollow threat. In other cases the property owners are victims of unscrupulous operators (tenants) and do not have the necessary resources to pay for cleanup.

The legal process to bring about the cleanup of waste tires by property owners or to conduct a CIMWB managed cleanup can take years and can be expensive. This process is initiated only after direct negotiations fail and the CIWMB has exhausted its administrative enforcement actions against the property owners.

The current plan (in accordance with statue, PRC §42889) is funding both long-term and short-term remediation of illegal waste tire sites with CIWMB-managed contracts. This plan proposes to move aggressively on both long and short-term projects and proposes to cleanup all sites currently listed. However, there remains a backlog of uninvestigated sites that may ultimately require state-funded cleanup after enforcement has failed. Although the Program plans to move expeditiously through this backlog, these enforcement efforts will take time as staff research property ownership, take appropriate enforcement actions, and attain site access in order to conduct site remediation activities. The Program will initially prioritize these sites to ensure that the sites which pose the greatest threat to public health and safety and the environment are addressed first.

The current data base system does not contain information on every illegal tire site in the state. As sites are identified, inspected, and processed, data are entered. If the state determines a need to remediate, the site will be added to the Site Remediation Listing. Also, cleanup monies are awarded based on PRC §42889 that is very specific in how the money will be expended.

Reference:

California Integrated Waste Management Board, Tire Management Web site. Posted at: www.ciwmb.ca.gov/Tires/default.htm

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Type III

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Number of environmental releases from active landfills

Despite the serious consequences that may arise from the migration of contaminants from landfills into soil, air or water, the extent and frequency of chemical releases from active landfills is unknown. Although such releases are tracked to some degree by various state and local agencies (such as those responsible for air quality, water quality and waste management), current regulatory requirements may permit only certain information to be collected from solid waste landfill owners and operations. The California Integrated Waste Management Board reports and tracks violations of "State Minimum Standards" at permitted solid waste facilities. These violations can be used to determine if further contamination/cross-media contamination investigation is needed. An indicator that tracks trends in environmental releases from active landfills would provide a meaningful measure of the effectiveness of structural and operational safeguards at these facilities in containing chemical contaminants.

Pesticides

Introduction

Pesticides are unique among environmental chemicals in that they are deliberately released to achieve a specific purpose. They are not an unwanted by-product of another process (such as an industrial operation); rather, they are produced specifically for their toxicity to a target pest. The regulation of pesticides does not focus solely on assessing toxicity, but also on managing risk by controlling exposure. The effects — beneficial, harmful or benign — of pesticides are dependent on several factors, the most important of which is exposure.

The Department of Pesticide Regulation (DPR) evaluates data on a pesticide to determine if it can be used safely in California. Controls imposed upon the use of a pesticide are designed to protect against adverse impacts on human health and the environment. If these controls are found to be ineffective, they may be modified, or if further modifications are not possible, the pesticide is banned from use.

The first pesticide-related law was passed in California in 1901, and today pesticide regulators have a comprehensive, science-based body of law and regulation to control every aspect of pesticide sales and use, to assess the impacts of that use, and to ensure protection of people and the environment. California has approximately 11,000 registered pesticide products. In 1990, California became the first state in the country to require full reporting of all agricultural pesticide use, expanding a system of limited reporting begun a half-century before. The state's program for reporting, investigating, and evaluating pesticide-related illnesses — designed to improve protection of workers and the public — was praised by the General Accounting Office in 1993 as a model for other states to follow.

Pesticide Indicators

Air

Number of detections of pesticides identified as toxic air contaminants and the percent that exceeds numerical health standards each year (Type III)

Water

Area with pesticides detected in well water (Type I)

Simazine and breakdown products in a monitoring network of 70 wells in Fresno and Tulare Counties (Type I)

Pesticide detections in surface water and the percent that exceeds water quality standards (Type III)

Pesticides in food

Percent of produce with illegal pesticide residues (Type I)

Pesticide use

Pesticide use volumes and acres treated, by toxicological and environmental impact categories (Type II)

Integrated pest management

Number of growers adopting reduced-risk pest management systems and the percent reduction in use of high risk-pesticides (based on Alliance grant targets) (Type II)

Human health

Number of reported occupational illnesses and injuries associated with pesticide exposure (Type I)

Ecological health

Number of reported fish and bird kills due to pesticide exposure each year (Type II)

Indicator

Number of detections of pesticides identified as toxic air contaminants and the percent that exceeds numerical health standards each year (Type III)

Issue 1: Air

Because pesticide use involves deliberately releasing chemicals to the environment to achieve a specific purpose, pesticides may adversely impact air quality. In California, the Toxic Air Contaminant (TAC) program created by Assembly Bill 1807 provides a statutory framework for the evaluation and control of air pollutants that may cause or contribute to increases in serious illness or death, or that may pose a present or potential hazard to human health. The Air Resources Board is the lead agency for the TAC Program, except for air contaminants that are registered and used as pesticides. The latter are regulated by the Department of Pesticide Regulation (DPR). A total of 37 pesticides have been designated as TACs. There are 200 pesticides identified as candidates for evaluation as TACs.

Indicators

Area with pesticides detected in well water (Type I)

Simazine and breakdown products in a monitoring network of 70 wells in Fresno and Tulare Counties (Type I)

Pesticide detections in surface water and the percent that exceeds water quality standards (Type III)

Issue 2: Water

Pesticides may impact water quality, affecting the suitability of the water for human consumption, for aquatic life, and other uses. Water contamination occurs following runoff of pesticides from treated fields or leaching into groundwater. Historically, investigations into pesticide contamination of water bodies have focused on agricultural activities. A number of regulatory efforts have focused on reducing agricultural sources of contaminants.

There is growing evidence that urban pesticide use is also a source of aquatic pollutants. Although urban pesticide applications are individually small, they involve a wide variety of chemicals and a relatively large number of small applications. Therefore, cumulative impacts may be significant. In some urban creeks, areas of extremely high concentrations ("hot spots") may occur.

Indicator

Percent of produce with illegal pesticide residues (Type I)

Issue 3: Residues in Food

If pesticides are used properly and according to label instructions, there should be no illegal residues on harvested produce. Tolerance levels for pesticide residues on produce are intended to protect against adverse impacts on human health. The presence of illegal residues may indicate improper or illegal pesticide use, as well as problems in the state's integrated network of pesticide regulatory programs. Illegal pesticide use can also adversely impact the health of wildlife and sensitive ecosystems.

Issue 4: Pesticide Use

Pesticides can be applied in a manner that increases the quality and production of agriculture and enhances public sanitation (water, food preparation, etc.). However, these benefits are not without risks to human health and the environment. Because pesticides are designed to be toxic to unwanted organisms, there are many public concerns about the widespread use of pesticides and the potential risks they pose to human and environmental health.

Indicator

Total pounds applied and cumulative acres treated by all pesticides in different toxicological and environmental impact categories in California each year (Type II)

Issue 5: Integrated Pest Management

Integrated pest management (IPM) is a long-term approach to managing pests combining biological, cultural, and chemical techniques in a program that is scientifically-based, economically sound, and beneficial to the environment. Pest management techniques may be utilized in a manner that benefits consumers, workers, the environment, and agriculture, without heavy reliance on pesticides. IPM is based on extensive monitoring to assess the levels of pests, and of natural enemies. Pest management decisions are made based on monitoring results, utilizing the most appropriate technique. Examples of IPM techniques include cover crops, crop rotation, crop sanitation to remove overwintering pests, release of natural enemies, pheromone confusion, use of products that act as insect growth regulators, and the selective, targeted use of chemical pesticides. Such pest management techniques avoid the hazards created by exposure to highly toxic pesticides.

Indicator

Number of growers adopting a reduced-risk pesticide pest management system and the percent reduction in use of high-risk pesticides (based on Alliance grant targets) (Type II)

Issue 6: Human Health

Pesticides have been associated with adverse effects on human health. Given the nature of their contact with pesticides, agricultural and pest control workers are most likely to face exposure to pesticides. The public may be exposed to pesticides in water, soil and air due to misuse or drift from sprayed areas. Consumers may face exposure from home-use pesticides, or to pesticide residues in food. Unacceptable risks may be avoided when pesticides are used properly, and when pesticide laws and regulations are enforced vigorously and consistently.

Indicator

Number of reported occupational illnesses and injuries associated with pesticide exposure (Type I)

Issue 7: Ecological Health

Pesticides are designed to be toxic to target pests. While their use instructions are intended to prevent adverse impacts on nontarget species, including wildlife, there have been instances when pesticide use has been linked to adverse impacts on birds, bees, and other nontarget species.

Indicator

Number of reported fish and bird kills due to pesticide exposure each year (Type II)

Type I

Level 4
Goal 3, 4

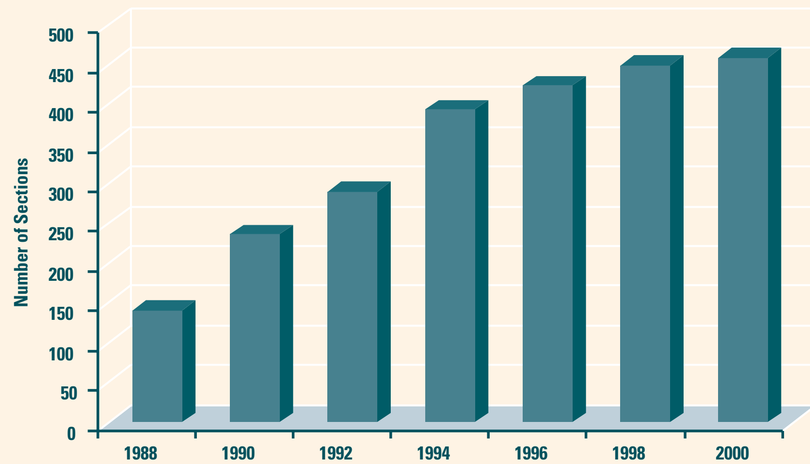
Area with Pesticides Detected in Well Water

In 2000, the cumulative land area where pesticide use is subject to special restrictions to protect groundwater totaled approximately 460 square miles.

What is the indicator showing?

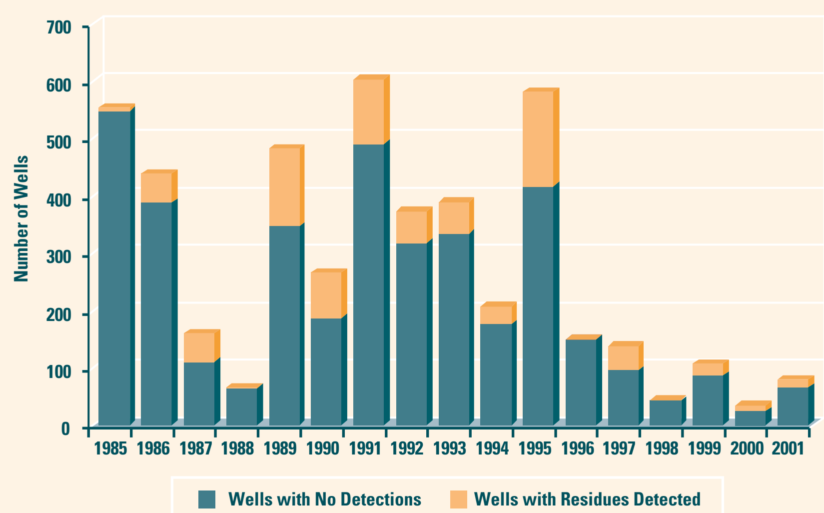
The indicator shows a cumulative measure of land area where the Department of Pesticide Regulation (DPR) regulates pesticide use for groundwater protection. Pesticide use is regulated in these areas because residues have been detected in well water as the result of legal non-point source applications. As of 2000, DPR regulates a total of approximately 460 square-mile sections of land. The addition of new regulated areas is dependent upon the discovery of pesticide residues in wells which, in turn, is related to sampling activity.

Cumulative Number of Sections* of Land where Pesticide Use is Regulated by DPR for Groundwater Protection



** A section is a one-square mile area based on the U.S. Geological Survey Public Land Survey coordinate system*

Number of Rural Wells Sampled Yearly by DPR and Number of Wells with Detection of Pesticide Residues



The companion graph shows the number of wells sampled yearly by DPR, and the number in which pesticides were detected. Sampling activity during the last five years has been much lower than the previous five years. In some years, nearly one-third of the wells sampled have contained pesticide residues.

Why is the indicator important?

The indicator presents the cumulative land area in California where pesticide use is subject to special restrictions to protect groundwater. One approach taken by DPR is to regulate pesticide use in sections of land where pesticide residues have been detected in well water, and where their presence was determined to result from legal, non-point source applications. These sections of land are regulated as "pesticide management zones" and reflect areas that are vulnerable to groundwater contamination by pesticides. A section of land is a one-square mile area based on the U.S. Geological Survey (USGS) Public Land Survey coordinate system.

DPR monitors the presence of pesticide residues in California's groundwater by obtaining samples of well water. Many wells are located in rural, agricultural settings. These areas are not routinely monitored by the Department of Health Services for compliance with drinking water standards, i.e., maximum contaminant levels (MCLs). Pesticide residues are periodically detected in new areas of the state. Well sampling data are used to identify those pesticides that pose a risk of groundwater contamination following application, and to delineate areas in the state where residues can move to groundwater. Based on this information, regulatory safeguards are formulated by DPR to protect against further groundwater contamination.

Since 1984, 16 pesticides and breakdown products have been detected in groundwater as the result of legal, agricultural use: 1,2-dichloropropane (1,2-D), 2-amino-4-chloro-6-ethylamino-s-triazine (ACET), aldicarb, aldicarb sulfone, aldicarb sulfoxide, atrazine, bentazon, bromacil, dibromochloropropane (DBCP), deethyl-atrazine, diuron, ethylene dibromide (EDB), norflurazon, prometon, simazine, and 2,3,5,6-tetrachloroterephthalic acid. DBCP, 1,2,-D, and EDB are no longer registered for use.

What factors influence this indicator?

Resources available to DPR for this activity limit the number of wells sampled annually. The graph depicts a decrease in the rate at which new sections of land have been added in recent years. The decrease in the number of new sections is related to a decrease in the number of wells sampled annually by DPR, rather than to a full accounting of the spatial extent of contamination in California. For example, in 1997 and 1998 a total of 182 wells were sampled, compared to 713 wells in the previous two years.

The Pesticide Contamination Prevention Act of 1985 (the Act) directed DPR to sample wells for pesticides that have a high potential to move to groundwater. The program obtains water samples primarily from rural domestic wells, which typically serve one household. These wells have a higher chance for detection of pesticide residues because they are usually shallower in depth than municipal wells and they are located within areas of intense pesticide use. The sampling program is voluntary, that is, well owners are solicited for their participation.

While this could be viewed as a limitation, the program has experienced a very high rate of cooperation so that this has not been a limiting factor.

Technical Considerations:

Data Characteristics

The well sampling program conducted by DPR targets specific pesticides that have a high potential for detection in groundwater, and the sampling is conducted in areas of the state where these pesticides are used. Data for determination of pesticide residues in well water samples are obtained by other state, local, and federal entities. State agencies must report well sampling for pesticide residues to DPR. This information is stored in the Well Inventory Database, which is maintained by DPR as mandated by law. The database contains 933,969 records for 21,187 unique wells. This information is also used to determine new sections where pesticide residues have been found. DPR responds to positive detections by analyzing the chemical analytical data, conducting site inspections, and re-sampling wells when appropriate.

Detections of new active ingredients in California's groundwater are subject to a decision-making process mandated by the Act. Regulatory decisions have ranged from suspension of use if no mitigation measures are available, to continued use of pesticides in sections when mitigation measures have been identified. The area of land where pesticide use is subject to special restrictions reflects only those sections where use is allowed according to the appropriate mitigation measure. Thus, the spatial extent of known groundwater contamination, as well as the impact of regulations, are underestimated. The data do not capture those land areas where groundwater contamination is known to have occurred where the regulatory action was to suspend use. For example, a study conducted in 1989 for the presence of bentazon in well water produced detections in 59 sections. Based on these detections, the regulatory decision was to suspend use on rice. These sections are not formally included in the count of sections where pesticides are regulated because the decision impacted all rice acreage.

Strengths and Limitations of the Data

The number of domestic wells sampled and the spatial coverage has varied annually in relation to budgetary constraints. The number of detections is also influenced by the detection limit of the analytical methods as well as pesticide use. For example, detection limits for many pesticides can be lower given today's analytical methods versus higher detection limits for analytical methods 10 to 20 years ago. Detections of specific pesticides may increase as pesticide use increases in a given geographic location.

As discussed earlier, the land area tracked by the indicator corresponds to those in which pesticide applications are regulated by DPR. Areas in which groundwater contamination had occurred, but where the regulatory response was to suspend the use of the pesticide, are not captured by this indicator.

Reference:

Guo, F., D. Bartkowiak, D. Weaver, J. Troiano, M. Pepple, F. Spurlock, and C. Nordmark. *Sampling for Pesticide Residues in California Well Water: 2000 Update of the Well Inventory Database*. EH 00-15, Environmental Monitoring and Assessment Branch, Department of Pesticide Regulation. Posted at: www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh0015.pdf

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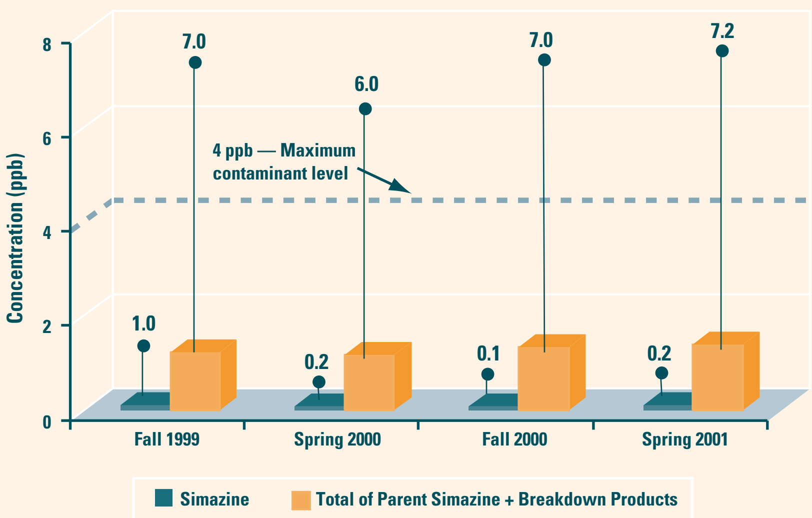
Simazine and Breakdown Products in a Monitoring Network of 70 Wells in Fresno and Tulare Counties

Concentrations are relatively stable over the past sampling periods.

Type I

Level 4
Goal 3, 4

Average (Bars) and Maximum (Points) Concentrations of Simazine and Total Residues of Triazine Detected in Rural Drinking Water Wells



What is the indicator showing?

Among 70 wells monitored in Fresno and Tulare Counties since 1999, detections of simazine have not exceeded the maximum contaminant level (4 parts per billion [ppb]), marked as the dashed line on the graph). Simazine breakdown products in the same water samples were found at higher concentrations; when all triazine residues are added together, their sum can exceed 4 ppb, as indicated by the plot of the maximum values measured.

Why is this indicator important?

The indicator presents data obtained from monitoring conducted by the Department of Pesticide Regulation (DPR) for the presence of simazine and its breakdown products in a network of wells in Fresno and Tulare Counties. Previous sampling studies have identified portions of these counties as vulnerable to groundwater contamination by pesticides. The indicator tracks a network of approximately 70 rural domestic wells that are a source of drinking water for primarily single-family residences, and that had previously been shown to contain pesticide residues. The wells are sampled in the spring and in the fall, starting in the fall of 1999. The concentrations measured are compared to a water quality standard. The indicator provides a direct measure of the potential exposure to simazine and its breakdown products in drinking water.

Simazine is a pre-emergence herbicide used to control annual grasses and broadleaf weeds in citrus orchards. It is widely used in the area of the monitoring well network. Residues have been detected in nearly all of the monitoring wells. The current California and national drinking water standard or “maximum contaminant level” (MCL) for simazine is four micrograms per liter, or four parts per billion (4 ppb). This standard was derived from the level determined to protect the most sensitive long-term adverse health effect (decreased body weight) as determined from a two-year cancer study in rats.

Results are also presented for simazine's breakdown products which, because of their structural similarity to simazine, are expected to exhibit similar toxicity; however, health standards have not yet been developed for the breakdown products.

Levels of simazine have not excceded the MCL. However, when concentrations of simazine and its breakdown products are added together, the sum exceeded the drinking water standard in approximately 10 percent of the wells each year. The maximum values are shown on the graph.

The data will be used to measure the success of DPR's regulatory program that is designed to prevent groundwater contamination through improved management practices. The regulations have not yet been enacted, so these data provide background information from which to determine the effectiveness of the regulatory changes. (An explanation of the changes being considered can be obtained from: www.cdpr.ca.gov/docs/empm/gwp_prog/gwp_prog.htm)

What factors influence this indicator?

Pesticide residues move to groundwater through a combination of geographic and management factors. The area in which these wells are located is intrinsically vulnerable to groundwater contamination based on predominant soil types and on the shallowness of the groundwater. Since water is necessary for the eventual movement of pesticide residues to wells, percolation and runoff of water produced from irrigation or rainfall events are the predominant ways in which pesticides move from sites of application. Management practices that either avoid contact with percolating or runoff water or that manage the amount of percolating or runoff water will influence the eventual frequency and magnitude of detections.

Technical Considerations:

Data Characteristics

The data are collected from DPR's sampling of a network of 70 wells in Fresno and Tulare Counties. The wells are rural, domestic wells that are sampled with the consent of the well owners. Each water sample is analyzed for ten chemicals, of which three are breakdown products of triazine herbicides. MCLs have been established for three of the parent pesticides. Residues of simazine have not been measured above its MCL.

Simazine has two major breakdown products that are detected in the sampled wells at higher concentrations and at greater frequencies than simazine itself. When the concentrations of parent simazine and its breakdown products are added together, the sum can exceed the 4 ppb MCL. Although the toxicity of the breakdown products is thought to be similar to the parent pesticide, a determination has not yet been made as to the toxicological significance of the total concentrations of simazine and its breakdown products relative to the MCL.

Strengths and Limitations of the Data

The data reflect only the condition of groundwater in the Fresno and Tulare Counties area. Pesticides are detected in other areas of California but resources do not support a comprehensive monitoring system. Under a recent proposal, the area represented by the well network will receive increased regulatory attention. Thus, monitoring the changes in residue concentrations over time will be an important indicator of the success of pollution prevention efforts. A long-term commitment to sampling is necessary because, even in areas of shallow groundwater, changes made at the soil surface will take at least five years (as determined from an age dating study conducted in this area [Spurlock, et al., 2000]) to affect concentrations measured in wells.

Comparison of the concentrations of the contaminants at the wells to the relevant MCL is used by the Department of Health Services to regulate public drinking water, including municipal wells. Domestic wells have not received the same level of monitoring as municipal well systems, and have not been subject to the same level of regulatory activity.

References:

Troiano, J., D. Weaver, J. Marade, F. Spurlock, M. Pepple, C. Nordmark, D. Bartkowiak. 2001. *Summary of Well Water Sampling in California to Detect Pesticide Residues Resulting from Nonpoint-Source Applications*. Journal of Environmental Quality 30:448-459.

Garretson, C. 1999. *Protocol for Monitoring the Concentration of Detected Pesticides in Wells Located in Highly Sensitive Areas*. Posted at: www.cdpr.ca.gov/docs/empm/pubs/protocol.htm

Spurlock, F., K. Burow, and N. Dubrovsky. 2000. *Chlorofluorocarbon Dating of Herbicide-Containing Well Waters in Fresno and Tulare Counties, California*. Journal of Environmental Quality 29:474-483.

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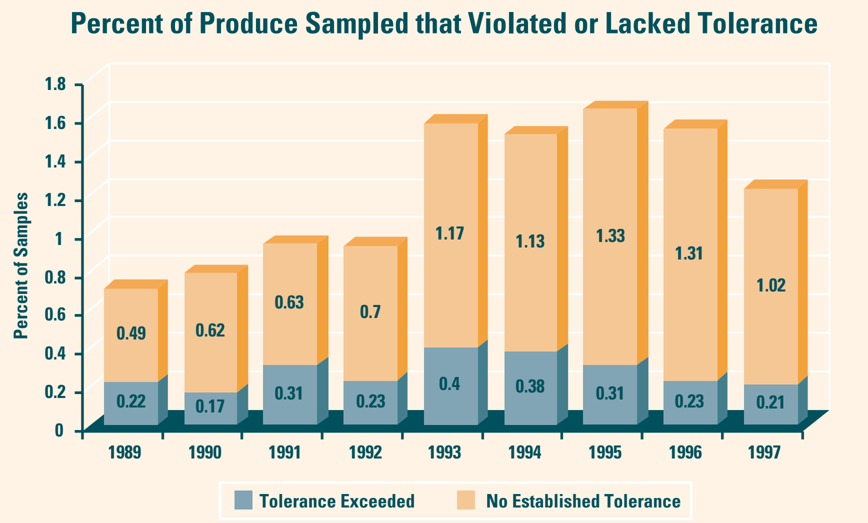
Type I

Level 4
Goal 4

Percent of Produce with Illegal Pesticide Residues

Illegal residues are detected in less than 2 percent of produce sampled.



What is the indicator showing?

From 1989 through 1997, less than 2 percent of produce samples had illegal pesticide residues. Of these, less than half a percent exceeded allowable levels (tolerances); a higher proportion contained residues for which allowable levels of the pesticide have not been established for the produce in which it was found.

Why is the indicator important?

The indicator shows the percentage of produce samples that contain illegal pesticide residues. Pesticide residues are illegal when they occur above regulatory "tolerance" levels established by U.S. Environmental Protection Agency (U.S. EPA), or when the pesticide is found on a commodity for which it is not registered (in such cases, no tolerance exists). A tolerance is established for a specific pesticide/commodity combination. U.S. EPA has established approximately 9,700 tolerance levels. These levels incorporate a margin of safety, and are intended to protect against adverse health effects. (Residues below a tolerance level are presumed not to pose a health concern.) Occasional consumption above tolerance level does not necessarily result in adverse effects.

This indicator characterizes the safety of produce in California by providing a direct measure of the level of pesticide residue in produce. Monitoring helps ensure that produce offered for sale complies with regulatory standards for pesticides in produce. Tracking pesticide residues is an important tool to enforce regulatory standards designed to prevent potentially harmful exposures to pesticide residues.

There are approximately 942 pesticide active ingredients registered with the U.S. EPA. Produce samples are routinely screened for the 200 most commonly used pesticides and breakdown products. Many samples are also analyzed for pesticides not on the residue screen.

The Department of Pesticide Regulation (DPR) investigates every case of illegal residue. If the produce originated outside of California, the information is forwarded to the U.S. Food and Drug Administration (FDA) for further enforcement action. If the produce was grown in California, DPR attempts to learn how it was contaminated before determining appropriate enforcement action. DPR, working with the county agricultural commissioners, has wide-ranging authority to deal with violators of pesticide laws and regulations.

What factors influence this indicator?

In California, samples of domestic and imported produce are taken throughout the channels of trade: at seaports and other points of entry into the state, packing sites, and wholesale and retail outlets. More than 7,000 samples taken annually are tested for more than 200 pesticides and breakdown products. Although the number of samples has varied over the past decade, the findings have been consistent from year to year: Most residues are below detectable limits. Residues that are found are usually at extremely low levels (a fraction of a part per million). Between 1989 to 1997, illegal residues were found in less than 1 percent of California-grown produce, and approximately 2 percent of foreign-grown produce. Violations commonly involve traces of pesticides not registered for the commodity on which they are found, often as a result of drift from adjacent applications, rather than from direct misuse of a pesticide on a commodity.

The effectiveness of DPR's monitoring program is enhanced by a formal cooperative agreement with the FDA, which has an extensive nationwide produce monitoring program. This cooperative agreement leads to a more comprehensive understanding of the incidence of pesticide residues in the food supply.

Technical Considerations:

Data Characteristics

The data are from the DPR Marketplace Surveillance Program. Samples are collected throughout the state from five different types of sites: wholesale markets, chain store distribution centers, retail outlets, field, and point of entry. Each sample is analyzed with a multi-residue screen capable of detecting more than 200 pesticides and breakdown products. Analysis is typically conducted within eight hours of collection.

Approximately 75 commodities are targeted annually. These commodities are chosen for reasons such as: history of violations; high market volumes; and dietary significance based on consumption frequencies, and/or consumption by infants and children at higher rates than adults.

Strengths and Limitations of the Data

California has the oldest and most comprehensive state monitoring program for fresh produce in the nation. Sampling is weighted toward such factors as patterns of pesticide use; relative number and volume of pesticides typically used on a commodity; relative dietary importance of the commodity; past monitoring results; and knowledge of local pesticide use. Therefore, the results may be biased toward finding produce more likely to contain illegal residues than if samples were collected randomly. In addition, the number of samples of a given commodity analyzed for a particular pesticide each year may not be sufficient to draw specific conclusions about the residue situation for the whole volume of that commodity in commerce.

Reference:
Department of Pesticide Regulation, Pesticide Residue Monitoring Program. Posted at: www.cdpr.ca.gov/docs/dprdocs/residue/resi1997/rsfr1997.htm

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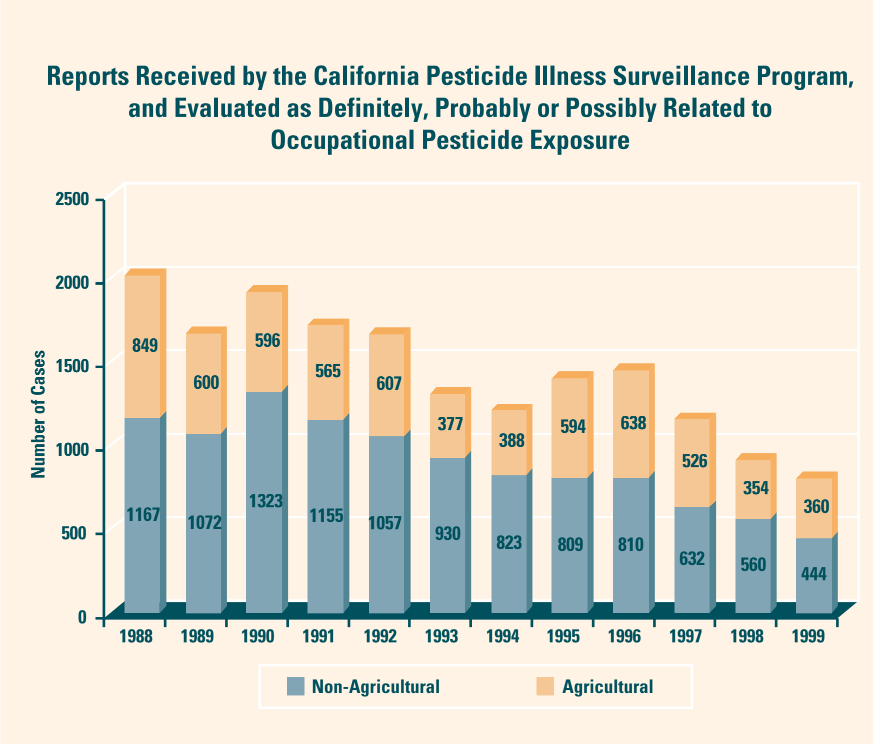
Number of Reported Occupational Illnesses and Injuries Associated with Pesticide Exposure

Pesticide-related illnesses and injuries have declined overall.

Type I

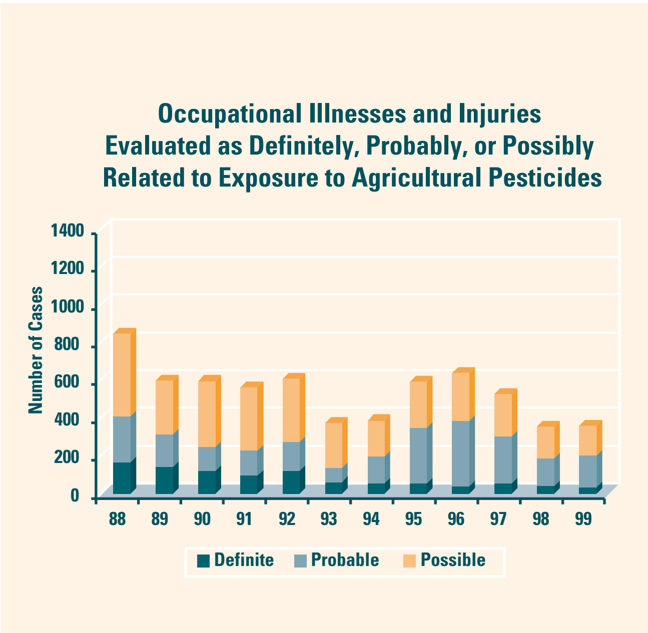
Level 6
Goal 4

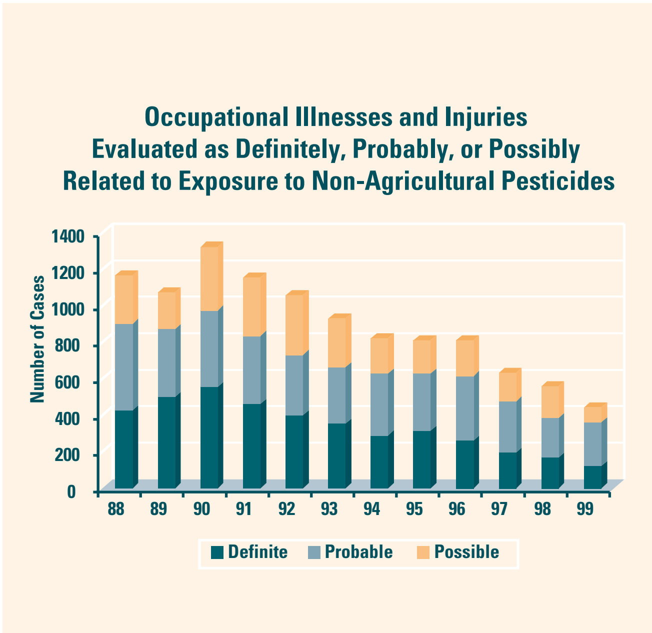


What is the indicator showing?

Reported pesticide-related illness and injury have declined over the past 11 years. More of the reported incidents are related to non-agricultural than to agricultural pesticides.

The graphs below show the number of occupational cases evaluated as definitely, probably or possibly related to pesticide exposure, according to the type of pesticide use.





Why is this indicator important?

This indicator is a direct measure of the immediate impact of pesticides on human health in the workplace. There are two categories of occupational illness cases: agricultural and non-agricultural. Tracking acute illnesses allows the identification and mitigation of situations that lead to excessive exposures, avoiding chronic as well as acute effects.

California's Pesticide Regulatory Program has tracked occupational pesticide-related illnesses and injuries since the early 1970s. (The graphs track cases beginning in 1988, the year when the variables collected and incorporated into the data base were expanded.) The Department of Pesticide Regulation (DPR) and county agricultural commissioners (CACs) seek out, investigate, record, and analyze incidents in which pesticide exposure appears to have harmed human health in the workplace. Trends in illnesses and injuries can be used as an indicator of the effectiveness of the pesticide regulatory program in protecting worker health and safety, in planning compliance and enforcement efforts, selecting exposure studies, and evaluating regulatory requirements. DPR has insufficient data to include non-occupational illness in this indicator. Non-occupational injuries are seldom reported for reasons stated below.

What factors influence this indicator?

Since 1971, California law has required that physicians contact their local health department whenever they suspect an illness or injury is related to pesticide exposure. Since physicians often do not report potential pesticide illnesses, DPR also reviews occupational illness reports submitted to the state workers' compensation system. There has been a distinct downward trend in most categories of workplace pesticide-related illnesses and injuries reported. This may reflect fewer occurrences of illnesses and injuries, fewer physician visits by persons exposed to pesticides, less recognition by physicians that a patient exhibits pesticide-related symptoms, or a decrease in the number of recognized cases reported through the system. Certain barriers prevent some workers from seeking medical care; also, patients may fail to relate pesticide exposure to symptoms they are experiencing. It seems likely, however, that the prevalence of these latter factors has not changed from a decade ago.

DPR constantly works to improve both workplace safety regulations and the ability to recognize the adverse effects of pesticides on human health. Several efforts have been initiated to improve pesticide illness reporting, including pesticide illness recognition training for health care professionals conducted by the Office of Environmental Health Hazard Assessment (OEHHA), and DPR's pesticide training for workers and alliance with the California Poison Control System. These efforts should increase the number of cases reported and investigated.

In some cases, a single incident can involve a large number of workers. Sudden jumps in case numbers generally reflect these types of occurrences, such as the Kern County incident when an application of a pesticide to cotton drifted into a vineyard where approximately 1,000 harvesters were at work.

Technical Considerations:

Data Characteristics

Physicians are required under state law to contact their local health department whenever they suspect an illness or injury is related to pesticide exposure. The health department notifies the CAC, and completes a pesticide illness report. Copies of this report are sent to OEHHA, the California Department of Industrial Relations, and DPR. Illness reports are also collected from the state workers' compensation system.

The indicator is based on cases where physicians reported any suspected or confirmed pesticide illness or injury in the workplace, and any cases reported under worker compensation claims. The CAC investigates each case to determine why and how the illness or injury occurred. Investigations begin when a report mentions a pesticide as a possible cause of injury. Reports that cite unspecified chemicals also prompt investigation if the incident occurs in a setting associated with pesticide use. DPR scientists use this information to determine the probability that an illness or injury was caused by the pesticide exposure.

Occupational cases involve persons exposed to pesticides at their workplace. This includes persons who mix, load and apply pesticides in agricultural, industrial, institutional and residential workplace settings, field workers who come in contact with pesticide residues on agricultural crops, or any other persons who come in contact with pesticides while on the job. "Agricultural" cases involve pesticides used to produce an agricultural commodity (e.g., crops, livestock), or accidentally released in these settings. "Non-agricultural" cases involve pesticides used or accidentally released in residential, institutional, industrial, and commercial settings.

OEHHA conducts physician training on pesticide illness recognition. Nevertheless, physicians may not always report potential pesticide illnesses.

Strengths and Limitations of the Data

California's surveillance program is the oldest and largest such effort in the United States. It is the only one to attempt to cover all types of pesticides and all occupational exposure scenarios. County agricultural commissioners conducted on-site investigations for over 95 percent of the case reports in the database, and trained scientists evaluate the investigation reports.

Heavy reliance on reports from the workers' compensation system inevitably biases the surveillance program toward occupational exposures. People injured off the job, or who fail to seek medical care after pesticide exposures, are not included. Non-occupational exposures are seldom reported. Reporting aspects of California's surveillance program also tend to emphasize acute rather than chronic illnesses related to pesticide exposures.

Reference:

Department of Pesticide Regulation. California Pesticide Illness Surveillance Program (1988 – 1999). Annual Summaries, posted at: www.cdpr.ca.gov/docs/dprdocs/docsmenu.htm

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Type II

Pesticide Use Volumes and Cumulative Acres Treated, by Toxicological and Environmental Impact Categories

In order to understand what effect pesticides have on the environment and human health, the first step is to know how much pesticide was actually applied, broken down by categories based on human toxicity and environmental impacts. Total volumes provide a measure of the amount applied in the environment; volume alone, however, can be misleading because different pesticides are applied at widely varying rates. A measure of the cumulative acres treated is not affected by the rate of use. Neither parameter provide a measure of pesticides' effects on the environment or human health.

All production agricultural pesticide use and some other kinds of uses must be reported to the Department of Pesticide Regulation. The information collected for each agricultural application includes what pesticide was applied, how much was applied, and the area treated. This full use reporting system has been operating since 1990 and all data are contained in the pesticide use report (PUR) database. Because the data represent a census of production agricultural use, rather than just a sample, they should be close to actual use. Also, the data are extensively checked for errors.

At present, the PUR data do not include all pesticide use. Home and garden use and most industrial and institutional uses are not covered by the reporting requirement. Regulations require that all pesticide use in production agriculture be reported. The percent of that use relative to the other categories of use is not known.

Reference:
Department of Pesticide Regulation. *Pesticide Use Reports 1990 – 1999*. Posted at: www.cdpr.ca.gov/docs/pur/purmain.htm

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Type II

Number of Growers who Adopt Reduced-Risk Pest Management Systems, and the Percent Reduction in Use of High-Risk Pesticides (Based on Alliance Grant targets)

DPR offers financial support through its reduced-risk grants program, consisting of two parts, the Pest Management Grants established in 1996, and Pest Management Alliance Grants, established in 1998. The goal of this program is to reduce the risks from pesticide use to people and the environment by promoting adoption of alternative pest management practices.

The program provides funding to encourage increased implementation of biologically intensive reduced-risk pest management through projects that address key areas of concern. Both Pest Management Grants and Alliance Grants demonstrate alternatives to highly toxic pesticides, protect surface and groundwater quality, and develop alternative reduced-risk approaches for urban pest management. Unlike the Pest Management Grants, which are small regional projects, Alliance Grants address some of the more important pest management issues on a regional or statewide scale. The grants provided

References:
Department of Pesticide Regulation. *Pesticide Use Reports 1990 – 1999*. Posted at: www.cdpr.ca.gov/docs/pur/purmain.htm

Grower surveys; progress and final reports of each grant; formal presentations; field meetings; publications and other outreach events.

under DPR's Pest Management Grants Program are grower-community-and-industry-driven projects providing education through demonstration and outreach.

This indicator will provide a measure of the adoption of reduced-risk management systems. The grants fund local, regional and statewide projects demonstrating reduced-risk alternatives. Measures of success are reported to DPR but data are currently insufficient to accurately measure the rate of adoption.

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Number of Reported Fish or Bird Kills/Year Due to Pesticide Use

Type II

The number of fish and bird kills each year that can be linked to pesticide use provides an indication of the ecological impacts of pesticides. This indicator will provide information that may indicate off-target movement of pesticides, the need for mitigation measures, or the need to re-evaluate a pesticide's toxicity, application methods (including dosage/rate/frequency of application), and cultural practices (a single or a series of farming practices, including irrigation that affect the release, spread, activity or effect of a pesticide). Fish or bird kills may result from secondary poisoning (i.e., when a predator or scavenger eats contaminated prey), and may directly or indirectly affect threatened or endangered species.

Data on fish or bird kills are derived from:

- Priority investigations, typically conducted by county agricultural commissioners within 48 hours of receipt of a notification from DPR or the U.S. Environmental Protection Agency; these investigations, which are addressed by a memorandum of understanding involving the latter agencies and the county agricultural commissioners, are commenced when an incident meets certain triggers – i.e., it involves at least 500 non-target fish, 50 non-target birds, or 1 endangered species;
- Pesticide Episode Investigation Reports (PEIRs) which cover routine investigations by the county agricultural commissioners of fish or bird kills that do not meet the triggers for priority investigations; the PEIRs are submitted to the local DPR regional office;
- Complaints received by the county agricultural commissioners or by DPR from citizens and other agencies;
- Referrals from agencies which, in the course of carrying out their responsibilities, come across information falling under the jurisdiction of the county agricultural commissioner or DPR;

References:

Cooperative Agreement between the State of California, Department of Pesticide Regulation, California Agricultural Commissioners and Sealers Association, and U.S. EPA, Region 9 (Enforcement Letter 2001-020). Posted at www.cdpr.ca.gov/docs/enfcmpli/penfltrs/penf2001/2001020.htm

Memorandum of Understanding between Department of Fish and Game, Department of Pesticide Regulation, and California Agricultural Commissioners and Sealers Association (Enforcement Letter 2000-030). Posted at www.cdpr.ca.gov/docs/enfcmpli/penfltrs/penf2000/2000030.htm

Pesticide/Wildlife Incident Response Plan (PWIRP) and Plan Agreement (Enforcement Letter 2000-030). Posted at www.cdpr.ca.gov/docs/enfcmpli/penfltrs/penf2000/2000030.htm

Priority Investigation Case Log (maintained on calendar year basis)

Pesticide Episode Incident Reports (PEIRs) (maintained in DPR Regional Offices)

(County) Episode Tracking Logs (maintained in DPR Regional Offices)

Complaints (maintained in DPR Regional Offices)

Referrals (maintained in DPR Regional Offices)

References (cont.)

Department of Fish and Game, Pesticide Investigations Unit. Fish and Wildlife Loss Inventory (maintained on calendar year basis)

Laboratory analyses of water, soil, foliage, swab, or tank mix samples for individual bird/fish kill incidents conducted by the California Department of Food and Agriculture, Center for Analytical Chemistry (maintained in the DPR Regional Office representing the county in which the incident occurred).

Laboratory analyses of bird/fish tissue conducted by the Department of Fish & Game (may be available from DPR's Pesticide Registration Branch).

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- Pesticide/Wildlife Incident Response Plan Agreement involving county agricultural commissioners, DPR, and the Department of Fish and Game (DFG), which establishes notification procedures for any pesticide incident involving fish or wildlife; and,

- Laboratory reports from DFG or the Department of Food and Agriculture.

No central database exists to track these incidents, or to query their human or environmental impacts. The data are maintained separately, and no effort is made to compare or to reconcile the different datasets. Hence, current data collection and management make trend analysis difficult. In most cases, the pesticide cannot be determined, or cannot be linked to a source (a known use or user) for a variety of reasons: obtaining evidence (tissue samples or environmental samples) for laboratory analysis is extremely difficult; the results of the analyses are inconclusive; and the location where contamination and subsequent fish or bird exposure occurred cannot be determined due to the mobility of the animals. It is also unknown whether the fish or bird kills tracked are a reasonable approximation of actual incidents. These incidents can occur without the county agricultural commissioners or other agencies being notified, as there is no incentive for a property operator or a pesticide applicator to report these incidents.

Type III

Pesticide Detections in Surface Water and the Percent that Exceeds Water Quality Standards

This indicator will present the frequency of pesticide detections in surface water, and the concentrations compared against applicable water quality standards. The Department of Pesticide Regulation (DPR) maintains a Surface Water Database that includes results from pesticide monitoring studies and toxicity testing. However, the monitoring that generated the data was not designed for long-term trend analysis. Protocols for long-term trend studies have not yet been adopted, and DPR is investigating the feasibility of a monitoring network.

As of July 15, 2000, the database contained the results of 30 studies conducted by federal, state, and local agencies, private industry, and an environmental group. The purpose of these studies was to characterize concentrations of pesticides at a particular site over a specific time period, not to characterize long-term trends. Sites were typically selected based on the likelihood that the water body had a high concentration of pesticides. The database catalogues the results from more than 4,600 samples taken in 16 counties from January 1991 through March 2000. Toxicity tests were performed on samples taken in 15 of the 30 studies. Each record in the database is the result of one analysis for a pesticide active ingredient or breakdown product, or an endpoint measurement taken during a toxicity test. The database contains approximately 92,000 analytical records and 3,300 toxicity test measurements.

Data on pesticide concentrations in surface waters would be compared against applicable water quality standards. At present, standards that protect public health and aquatic habitats have not been developed for all pesticides. Where standards do exist, they may change over time, or multiple levels for the same pesticide may exist, causing confusion as to which level is most appropriate. There has been increased concern about the effects of surface water contaminants on ecosystem health. Currently, Total Maximum Daily Loads (TMDLs) are being developed by Regional Water Quality Control Boards to address inputs of contaminants in aquatic environments. After TMDLs are developed, waterbody-specific targets for contaminants, including pesticides, will be adopted.

Reference:
Department of Pesticide Regulation, Surface Water Database. Posted at: www.cdpr.ca.gov/docs/surfwatr/surfdata.htm

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Number of Detections of Pesticides Identified as Toxic Air Contaminants and the Percent that Exceeds Numerical Health Standards Each Year

Type III

This indicator will reflect the frequency of detection of pesticides designated as toxic air contaminants (TACs); furthermore, measured concentrations will be compared against numeric health standards. These standards have not yet been determined, but will be set at a level intended to protect against potential adverse impacts on human health.

Thirty-seven pesticides have been designated as TACs in Title 3, California Code of Regulations, Section 6860 (both Department of Pesticide Regulation [DPR]-designated pesticides and federal hazardous air pollutants). California has established most of the scientific, regulatory, and administrative infrastructure to implement this indicator. State law mandates the key elements of the TAC Program. Sampling and laboratory methods have been validated for most TACs. DPR and the Air Resources Board (ARB) have established procedures and resources to monitor for pesticides, determine exposures, and estimate risk. However, there are significant shortcomings to using the existing program as an environmental indicator.

PESTICIDES

Reference:
Air Resources Board, Pesticide Air Monitoring Studies for the Toxic Air Contaminant Program. Posted at: www.cdpr.ca.gov/docs/empm/pubs/tac/tacstdys.htm

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This environmental indicator requires a network of stations that monitors the air on a regular basis. California has no such network for pesticides. The TAC Program is a collection of individual projects. At the request of DPR, ARB monitors for pesticides that are candidate TACs to gather information to assist DPR in the identification of a pesticide as a TAC. Little monitoring has been conducted for the pesticides already designated as TACs, particularly the 34 federal hazardous air pollutants that were designated administratively. Currently, monitoring occurs in areas where the most pesticides are applied, normally rural agricultural areas. Monitoring normally occurs for a few weeks during a single season of high use. The area and season of highest use vary among pesticides. Monitoring collects pesticides that are in the air as a result of application, drift, and post-application volatilization and offsite movement. However, the monitoring methods are optimized to collect gas-phase pesticides, and drift may not be collected efficiently. Additionally, the drift that is detected cannot be segregated from the gas-phase pesticides.

The ARB monitoring network for TACs currently focuses on non-pesticides in urban areas. DPR would need to establish a monitoring network for pesticides to implement this environmental indicator.

Transboundary Issues

Introduction

The movement of certain pollutants by natural processes, meteorological forces and human activities can produce environmental threats that extend beyond California's geographical boundaries, in some cases producing global impacts. For example, the worldwide emissions of greenhouse gases into the earth's atmosphere may result in global temperature and climate changes. Emissions of chlorofluorocarbons may result in global stratospheric ozone depletion.

Pollutants that originate in other states, countries or ecosystems, carried by atmospheric air currents, watersheds, trade, and travel can impact California; conversely, the same mechanisms can transport pollutants from California to other jurisdictions. For example, non-native organisms can enter the state's borders with the movement of people and goods. Ballast water in ocean-going vessels has been shown to be a carrier of alien aquatic species. Hazardous wastes are transported to and from California's borders for treatment or disposal. Air emissions from California may move into neighboring states, and vice-versa. Of special interest is the California/Mexico border region, the area within 100 kilometers of either side of the border.

Transboundary Indicators

Global pollution

Climate change

Carbon dioxide emissions (Type I)

Air temperature (Type I)

Annual Sierra Nevada snowmelt runoff (Type I)

Sea level rise in California (Type I)

Stratospheric ozone

Stratospheric ozone depletion (Type I)

Trans-border pollution

California-Baja California, Mexico border issues

Air pollutants at the California/Baja California, Mexico border (Type I)

Domestic border issues

Amount of hazardous waste imported/exported (See Land, Waste and Materials Management Section) (Type II)

International border issues

Ballast water program (Type III)

Issue 1: Global Pollution

Environmental pollution can produce adverse impacts locally (or in proximity to the source of the pollution), regionally, nationally and, in certain cases, globally. Air masses and ocean currents follow circulation patterns that can disperse pollutants and contaminate even the most remote and pristine environments on the planet.

Indicators

Carbon dioxide emissions (Type I)

Air temperature (Type I)

Annual Sierra Nevada snowmelt runoff (Type I)

Sea level rise in California (Type I)

Sub-issue 1: Climate change

The term "climate change" refers to changes in climate over time, with "climate" being defined as the average pattern of weather for a particular region. Elements of the climate include temperature, precipitation, humidity, wind velocity, phenomena such as fog, frost, and hailstorms, and other measures of the weather. Since the earth's climate is never static, however, the term climate change is used to imply a significant change from one climatic condition to another (U.S. EPA, 1999). Such changes can be due to natural processes (such as ice age cycles), or to human activities, such as alteration in the atmospheric concentration of certain gases, commonly referred to as "greenhouse gases" (GHGs).

GHGs, which are emitted from both natural and anthropogenic sources, include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorocarbons and chlorofluorocarbons. These gases play a role in the "greenhouse effect," a natural phenomenon that helps regulate the temperature of the earth. Simply put, the sun heats the earth and some of this heat, rather than escaping back to space, is trapped in the atmosphere by clouds and GHGs. The effect of this is to warm the earth's surface and the lower atmosphere. (U.S. EPA, 1999).

Scientists believe that human activities are increasing the atmospheric concentrations and distributions of GHGs, leading to a phenomenon known as global warming. CO_2 from the combustion of fossil fuels is the largest source of GHG emissions (about 80 percent of United States GHG emissions and about 87 percent of California emissions). The United States emits 25 percent of the world's CO_2, the European Union 16 percent, China 12 percent, and Japan and Australia 8 percent. Examples of other sources of GHGs include CH_4 emissions from landfills and N_2O from agriculture and combustion. Atmospheric concentrations of GHGs have sharply increased since the Industrial Revolution.

The National Research Council (NRC, 2001a) climate change analysis requested by President George W. Bush and the Third Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) conclude that the global climate is changing at a rate unmatched in the past one thousand years. The IPCC assessment cites new and stronger evidence that most of the global warming observed over the last fifty years is attributable to human activities and that anthropogenic climate change will persist for many centuries. However, while the NRC report generally agrees with the IPCC's Third Assessment, it does not rule out that some significant part of these changes is also a reflection of natural variability. The observed changes over the last fifty years and those projected for the future include sea level rise, higher maximum air temperatures, more hot days, fewer cold days, and greater extremes of drying and heavy rainfall. A more recent report from the NRC cites that in the earth's past, there were episodes of abrupt climate changes during periods of gradual temperature changes. GHG warming and other human alterations of the earth's system may increase the possibility of large, abrupt, and unwelcome regional or global climatic events (NRC, 2001b).

Climate changes can have profound impacts on human health directly through higher temperatures and increased frequency of heat waves, or indirectly, by increasing concentrations of ground-level ozone (O_3) or increasing the risk of some infectious diseases. Rapid changes in climate can disrupt ecosystems and negatively impact many species by, among other things, altering water and food availability. Further, agriculture, forestry, fisheries and water resources can be adversely impacted, resulting in severe economic consequences.

The 1992 United Nations Framework Convention on Climate Change aimed to stabilize atmospheric GHGs concentrations at a level that would prevent dangerous interference with the climate system. As part of the Convention, national inventories of anthropogenic GHG emissions are to be published and periodically updated. In 1997, the Kyoto Protocol was adopted to move the international community closer to achieving the Convention's objective. The parties to the Kyoto Protocol have agreed to legally binding commitments to reduce the collective emissions of six types of GHGs by at least 5.2 percent of the 1990 levels by 2012. In order for the Kyoto Protocol to take effect, it must be ratified by 55 percent of the countries representing at least 55 percent of the global CO_2 output from industrial countries. As of September 2001, 39 developing nations have ratified the Kyoto Protocol, including one industrialized nation, Romania. The United States and the major European nations have not ratified the Protocol.

The State of California continues to be a leader in efforts to address global climate change, with legislation and programs in place to improve energy efficiency, promote renewable energy sources, and lower emissions from the transportation sector. Senate Bill 1771 (enacted as Chapter 1018, Statutes of 2000) mandated the creation of a voluntary GHG registry aimed at recognizing California companies and organizations that make efforts to record and reduce their GHG emissions. The California Climate Action Registry has offices in Los Angeles and is developing a website at www.climateregistry.org. A Joint Agency Climate Team, consisting of the California Resources Agency, Cal/EPA and other state agencies, has been established to coordinate and integrate program activities related to climate change. Such activities include climate policy, research and technology development, and public information dissemination. The Climate Change Program of the California Energy Commission (CEC) is responsible for developing policies and programs to reduce GHG emissions statewide. In addition, the CEC's Public Interest Energy Research (PIER) Program currently funds research on the potential impacts of climate change in California.

Environmental indicators have been selected to help track certain parameters of climate change and GHG as they relate to California.

Indicator

Stratospheric ozone depletion (Type I)

Sub-issue 2: Stratospheric ozone

Stratospheric ozone formed in the upper atmosphere 6 to 39 miles high protects the earth's surface from much of the harmful ultraviolet (UV) light rays that are emitted by the sun. Until the late 1990s, increasing levels of chlorine and bromine in the stratosphere, originating primarily from chlorofluorocarbon emissions at ground level, have resulted in degradation of stratospheric ozone. Lower levels of stratospheric ozone may lead to higher amounts of UV radiation reaching the earth's surface. Exposure to excessive UV radiation has been linked to increased incidence of skin cancer and eye cataracts, damage to crops and aquatic organisms, and deterioration of synthetic materials. Over North America, including California, cumulative losses of about 10 percent in the winter/spring and a 5 percent loss in the summer/autumn, have occurred since the mid-1960s. Additional atmospheric processes over the Polar Regions cause seasonally greater depletion of stratospheric ozone, such that a recurring ozone "hole" often forms over Antarctica.

The 1987 Montreal Protocol established timetables for phasing out ozone-depleting substances. Peak values of ozone-depleting substances in the lower stratosphere appear to have been reached around 1997-98; however, they have remained at high levels, and ozone depletion is continuing as a result of past emissions. Hydrochlorofluorocarbons (HCFCs), which have largely replaced CFCs, generally have less than 5 percent of the ozone-depleting potential of CFCs. HCFCs have many of the same uses as CFCs and are increasingly employed as interim substitutes for CFCs. Due to their ozone-depleting and global warming potential, the production of these compounds will likely be phased out by the year 2030.

Ozone depletion over California has been monitored from a site near Fresno since 1983. Other longer running monitoring sites at similar latitudes in the continental United States have documented losses for over 20 years. However, the lack of long-term monitoring of surface UV levels along with other uncertainties cannot, as yet, determine if ozone depletion over California will result in an increased UV exposure to the public.

Issue 2: Trans-Border Pollution

The regulation of sources of pollution is traditionally undertaken to protect the citizens of a political jurisdiction from the deleterious effects of exposure to a hazardous substance. Pollution does not necessarily cease to become a threat to human health and the environment when crossing from the jurisdiction of one country into another.

Sub-issue 2.1: California/Baja California, Mexico border issues

California and Baja California, Mexico have cultures, legal structures, and social and economic interactions that create a unique set of environmental issues in this region. The border region is defined as the area within 100 kilometers of either side of the border. The Border Environmental Program (BEP) was established to address common concerns along the border. The Program consists of a multi-disciplinary group of professionals representing the states of California and Baja California. California is represented by Cal/EPA, the Resources Agency, the Department of Health Services, the Trade and Commerce Agency, the Department of Justice, and the Governor's Office of Emergency Services. Baja California is represented by the Ecology Directorate, the State Public Services Commissions, the Federal Attorney General's Officer for Environmental Protection (PROFEPA), and the Secretariat of the Environment and Natural Resources (SEMARNAT). The Border Affairs Unit within Cal/EPA directs the BEP; 22 Border Coordinators throughout Cal/EPA work with their individual departments and Mexican counterparts.

Hazardous waste

Under the North American Free Trade Agreement (NAFTA), United States (U.S.) companies that build maquiladoras, assembly plants in Mexico that import raw material and export finished goods to other countries, must ship hazardous waste produced at these facilities back to the United States. Some wastes do come back as properly documented hazardous waste (i.e., with a hazardous waste manifest), while other wastes are relabeled as product and sent to recycling firms in California.

On-site dumping of waste is occurring at Mexican maquiladoras, creating potentially hazardous working conditions and public health threats to nearby communities. In addition, an increasing number of abandoned waste sites are being identified in close proximity to communities.

Pesticides

U.S. Environmental Protection Agency- and California-registered pesticides purchased in the U.S. may legally be used in Mexico on commodities for which use is not legal in this country. Consequently, fresh produce from that nation may have illegal pesticide residues. Although still low, the violative rate of illegal residues on Mexican imported produce is twice the rate for domestic produce. Moreover, the protective measures mandated on the U.S. authorized product label may not always be followed in another nation, creating a potential for environmental contamination and worker exposure. Mexican agricultural workers in the U.S. made ill by pesticide exposure may be more likely to seek medical care in Mexico. In addition, highly toxic pesticide products produced in Mexico are illegally imported into the U.S. and used in residential settings for pest control, with associated problems of illness and environmental contamination.

Water pollution

The New and Tijuana Rivers flow from Baja California across the Southern California border. Both rivers are considered impaired water bodies, under California and federal laws, due to serious chemical and pathogenic contamination. Wastewater is not fully treated in most border cities. Severe water shortages are projected in border communities due to water pollution, industrial demand, and population growth. Increased salinization and the nutrient loading of the Salton Sea, partly as a result of inflow from the New River, are causing fish kills that can adversely affect migratory birds.

Indicator

Air pollutants at the California/ Baja California, Mexico border (Type I)

Air pollution

Air pollutants from mobile and stationary sources and from agriculture are transported both north and south across the border. Most cars in Baja California are older and lack emission controls. Traffic congestion at border crossings may significantly contribute to air pollution on both sides of the border. Unpaved roads and agricultural practices, such as burning and plowing, contribute to high particulate levels.

Sub-issue 2.2: Domestic border issues

California shares air basins and watersheds with three other U.S. states — Oregon, Nevada, and Arizona. Air pollution generated by industrial facilities and vehicular traffic in California can be carried by winds and primarily affect air quality of these neighboring states. Water quality concerns also exist; for example, issues relating to the Lake Tahoe watershed are shared by both Nevada and California.

The interstate movement of goods can lead to the introduction of plants and animals that are not indigenous to California. For example, fruit orchard infestations of the red imported fire ants in the agricultural regions of California's San Joaquin Valley have been traced back to colonies that hitchhiked on beehives shipped to California from Texas; the star thistle weed probably arrived in alfalfa shipments, and the mediterranean fruit fly (native to the Hawaiian Islands and various parts of the world) and glassy-winged sharpshooter fly (native to the southeastern U.S. and northeastern Mexico) in nursery stock and ornamental plants. California has suffered significant ecological and economic losses as a result of these and other non-indigenous species.

Another domestic border issue is the export and import of hazardous waste to and from other states in the U.S.

Indicator

Amount of hazardous waste imported/exported (see Land, Waste and Materials Management Section)

Sub-issue 2.3: International border issues

Pollutants in one ecosystem can often be traced to sources of pollution hundreds or thousands of miles away. International border issues may arise from the import and export of produce as well as legal and illegal products and wastes. The shipment of hazardous wastes from California to other countries raises public health and environmental equity concerns.

In addition to chemical pollutants, plants and animals that are not indigenous to California have been introduced into the state. These can compete with, and even eliminate indigenous species, leading to devastating consequences, such as the disruption of aquatic ecosystems by non-indigenous species carried in ballast waters in international ocean-going vessels.

Indicator

Ballast water program (Type III)

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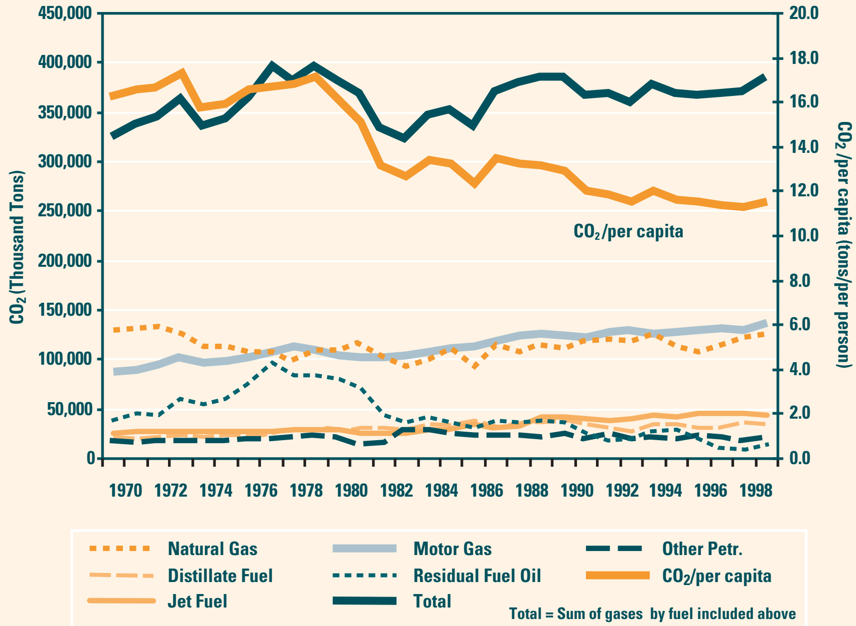
Type I

Level 3
Goal 4

Carbon Dioxide Emissions

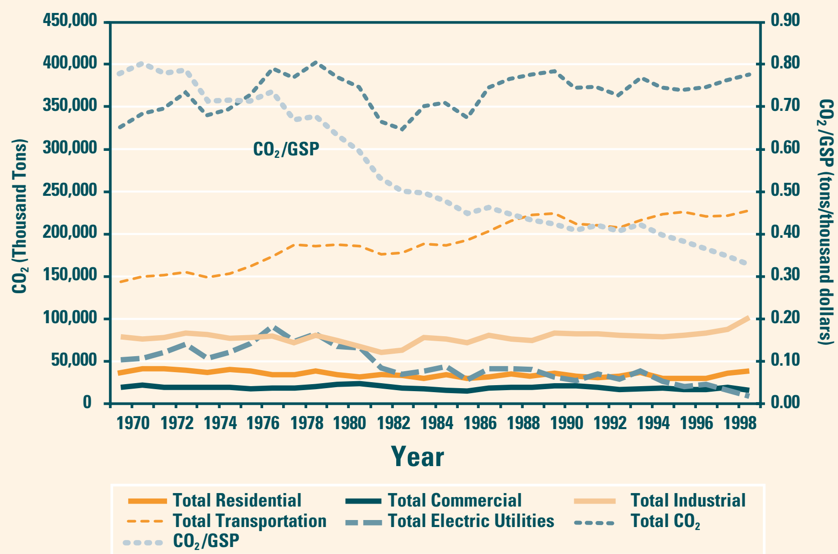
Emissions have increased slightly since the 1970s.

CO_2 Emissions by Fuel Type: 1970 – 1999



Source: California Energy Commission, 2001

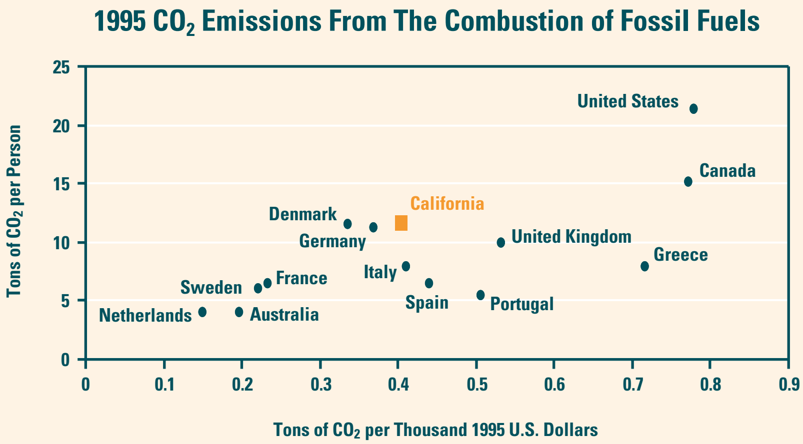
CO_2 Emissions by Sector: 1970 – 1999



Source: California Energy Commission, 2001

What is the indicator showing?

California emissions of carbon dioxide (CO_2) from the burning of fossil fuels have increased slightly from 1970 to 1999. However, emissions on both a per capita and per \$1,000 gross state product (GSP) basis have been decreasing, with the latter at a more rapid rate (Franco, 2001).



Source: California Energy Commission, 2001

What is the indicator showing?

For both CO_2 emissions per capita and per \$1,000 of the economy, the California average is lower than the average for the rest of the United States and Canada. The state's economy produces CO_2 at a lower rate than five other developed countries (see graph) (CEC, 2001).

Why is this indicator important?

CO_2 emissions from the combustion of fossil fuels account for the largest proportion of greenhouse gas emissions (GHG). The California Energy Commission (CEC) estimates that CO_2 represents approximately 87 percent of the "global warming potential" (GWP) of California's GHG emissions. The GWP is an index used to translate the level of emissions of various GHGs into a common measure based on their potential to cause global warming, usually compared to CO_2.

GHGs in the atmosphere retain heat that is radiated by the earth's surface back into space. These gases include both natural gases emitted from natural and anthropogenic sources, such as CO_2, methane (CH_4), and nitrous oxide (N_2O), and synthetic chemicals, such as hydrofluorocarbons (HFC). Atmospheric concentrations of GHGs have increased since the Industrial Revolution, enhancing the heat-trapping capability of the earth's atmosphere. Tracking trends in CO_2 emissions from fossil fuel combustion will allow an assessment of the state's contributions to global GHG emissions.

What factors influence this indicator?

Levels of CO_2 emissions are based upon patterns of fossil fuel consumption, which in turn are influenced by a number of factors, including population growth, motor vehicle miles traveled, economic conditions, energy prices, technological changes resulting in improved energy efficiency, the availability of non-fossil alternatives, consumer behavior, and weather. For example, improved economic conditions can result in an increased number of motor vehicles and increased motor vehicle miles traveled. Most of the emissions of CO_2 in California are generated from motor vehicle use and electrical power generation. Coal use in California accounts for only two percent of the total emissions from fuel combustion (CEC, 1998), although California imports electricity from other states that do use coal. (Coal generates more CO_2

emissions than other fuels used to produce electrical power.) Emissions from electricity generated out of state are not in the California emissions inventory because national and international convention requires the CEC to include only in-state fuel consumption in the emissions inventory. If this power were generated in California by power plants in compliance with state laws and regulations, these in-state emissions would have increased in the 1990s by about 5 to 11 percent. Due to its relatively mild weather, California's heating-related fuel consumption tends to be lower than many other states'.

The adoption and implementation of policies at the state, national and international levels can have a significant impact upon CO_2 emissions. The objective of the 1992 United Nations Framework Convention on Climate Change was to achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Parties to the convention agreed to prepare inventories of GHG emissions that originate from human activities and removals of CO_2 by carbon sinks. The 1997 Kyoto Protocol set legally binding targets for the reduction of six GHGs by at least five percent of 1990 levels by 2012.

The indicator illustrates that total emissions in California have not gone up significantly since the 1970s. This is, in part, due to the shift from residual fuel oil to natural gas in California's power plants. Residual fuel oil emits more carbon dioxide per unit of heat released during combustion than natural gas. The shift to natural gas was the result of lower natural gas prices in the past and stringent air quality regulatory requirements. Other state policies such as energy conservation programs have also contributed to the pattern of emissions. One other reason CO_2 emissions have remained relatively stable over the past 30 years may be attributed to the higher fuel economy of newer motor vehicles and the retirement of older, less fuel efficient motor vehicles.

In the past, California has imported about 33 percent of its electricity from other states. To meet the state's electricity demand, more power plants are being constructed. Fossil fuel consumption from these new power plants may increase the in-state CO_2 emissions. However, this will be tempered by the fact that the new power units will be much more efficient than many current power plants in operation and therefore produce much less CO_2 emissions per unit of electricity generated.

The decline in CO_2 emissions per $1,000 GSP is an indication of the increased energy efficiency of the economy, a higher reliance on fuels with lower carbon content, and a structural shift to a service-oriented economy. Increases in CO_2 emissions in the transportation sector are driven, in part, by the increase in motor gasoline consumption due to increased vehicle miles traveled, and the increased use of jet fuel due to increased air transportation (CEC, 1998).

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Technical Considerations:

Data Characteristics

The indicator is based upon fossil fuel use data in California starting in 1970. The next update to the statewide GHG Emissions Inventory from the CEC will be released by January 2002. As was done for the previous inventory (CEC, 1998), the update will include CH_4 and N_2O emissions and, for the first time, address all of the other gases covered by the Kyoto protocol. For the non-CO_2 gases, the inventory will cover the period starting in 1990 to the most recent year with complete energy and non-energy data necessary to estimate emissions. For easy comparison, all the emissions will be reported as CO_2 equivalents using their respective Global Warming Potentials (GWP).

Strengths and Limitations of the Data

The indicator accounts for only one GHG, and is based upon fossil fuels only. Emissions of other GHGs and CO_2 emissions from sources other than fossil fuels would provide a more complete picture of California's total emissions of GHGs. However, since CO_2 from fossil fuel combustion makes up almost 90 percent of the GWP of all GHG emissions (IPCC, 2001), the indicator is a reasonable approximation of California's contributions to global concentrations of GHGs. As more information becomes available for emissions of GHGs other than CO_2, or non-fossil fuel sources of CO_2, consideration will be given to expansion of the CO_2 indicators for climate change.

CH_4 is the main constituent of natural gas and has a GWP 21 times that of CO_2. CH_4 is also formed as a result of solid waste landfill decomposition of organic matter in an anaerobic environment, and from livestock digestive processes and manure management. N_2O emissions from fertilizer use in agricultural soil management are based on data from the Department of Food and Agriculture's Materials Tonnage Report (CEC, 1998). N_2O has a GWP 310 times that of CO_2.

National and state-level inventories should not count emissions due to the consumption of fuels used for international transport. The amount of fuel purchased in California and used for international transport is expected to be significant due to its geographical location. However, the task of subtracting these fuels from the state consumption statistics is extremely difficult. For this reason, the data presented in the above figures include fuels purchased in California and used for international transport. Future updates to the state-level inventory prepared by the CEC will try to estimate the consumption of these fuels since 1990, which is considered as a baseline year in most GHG policy initiatives.

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Type I

Level 4
Goal 4

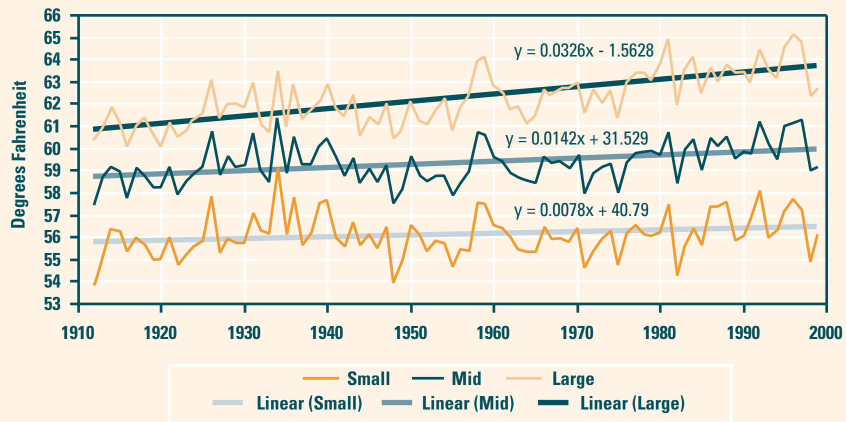
What is the indicator showing?

Air temperature has increased over the past 90 years, more so in large cities than in rural areas. Large urban areas are generally warmer than rural areas, and can have temperatures up to 5 degrees Fahrenheit (°F) higher, creating their own weather belt. This can be due to the removal of vegetation and trees, the presence of buildings and streets (which reflect heat stored in pavement), and the production of heat by human activities. The indicator illustrates trends of average yearly temperatures for three groups of counties. Counties with the largest populations (over one million residents) had the highest temperature increase. Conversely, counties with less than 100,000 people had the lowest average rate of temperature increase. These tend to be rural areas and are more likely to be representative of global influences, natural and man-made. The temperature increase rate of 0.7° F (0.5° C) per century from the rural group agrees with a global estimated mean surface temperature increase of 0.5 to 1.0° F (0.3 to 0.6° C) since the 19th century.

Air Temperature

Air temperatures have increased 0.7 to 3.0° F in the past century.

Average Temperature at 93 California Stations
Stratified by 1990 County Population
Large over 1 Million, Small less than 100,000



Source: James Goodridge, 2001

Why is the indicator important?

Average global earth surface temperatures have indicated an increase of 0.5° to 1.0°F since the late 19th century. The 20th century's ten warmest years all occurred in the last 15 years of the century. Seventeen of the eighteen warmest years in the 20th century occurred since 1980. In 1998, the global temperature set a new record, exceeding that of the previous record year, 1997 (National Assessment Synthesis Team, 2000). The graph presented here reflects California's temperature trend.

The indicator will track trends in statewide surface air temperatures and regional variations, allowing for a comparison of temperature changes in California with those occurring globally. Temperature data have been collected at many weather stations in the state for almost a century.

What factors influence this indicator?

According to the United Nation's Intergovernmental Panel on Climate Change (IPCC, 2001), human activities, including the combustion of fossil fuels such as coal and oil, land use changes and agriculture, are increasing the atmospheric concentrations of greenhouse gases (GHGs). Other than water aerosols, carbon dioxide (CO_2) is the most predominant GHG. Other GHGs are methane and nitrous oxide. These GHGs retain heat that would have been radiated from the earth back into space. Increases in the concentrations of GHGs are predicted to change regional and global climate and climate-related parameters such as temperature, precipitation, soil moisture, and sea level (NARIP, 1997).

Local geographical features affect temperatures in the many diverse areas that make up California. In fact, on any given summer day, California may experience both the hottest and the coldest air temperatures in the continental United States. Ocean currents upwelling and sea surface temperatures along the coast of California influence air temperatures; seasonal variations also occur (Union of Concerned Scientists, 1999). Changes in temperature and flow patterns in the Northern Pacific (Hare, 2000) and in the Eastern tropical Pacific (El Nino Southern Oscillation) cause variations in storm tracks affecting California. The mountains are also a strong influence and sometimes create their own weather. It is possible that changing vegetation cover and the evaporative cooling effects of irrigated crops in the Central Valley may influence summer temperatures to a slight degree.

Research is underway to integrate recorded temperature data from the past century and millennia with other climate-related data. Some research examples include tree ring analyses, fossil sediment records, CO_2 uptake by plants, snowmelt runoff, sea level rise, sea waves, precipitation amounts, storm and drought events, soil moisture, and various cycles of solar activity.

Evidence suggests that global warming rates as large as 3.6° F (2°C) per millennium may have occurred during the retreat of the glaciers following the most recent ice age about 20,000 years ago (National Research Council, 2001; U.S. EPA).

Technical Considerations:

Data Characteristics

California temperature data from the Western Regional Climate Center located in Reno, Nevada were collated and studied by James Goodridge. Average yearly temperature data from 93 recording stations located throughout California were stratified by county population size into three groups: sites in counties with a population of over one million persons; sites in counties with a population of less than 100,000; and sites in counties with populations that fall in between.

Strengths and Limitations of the Data

The location of the temperature recording stations may not have remained consistent over the years. The rural stations tend to be biased toward interior (eastern) counties of California, while most of the other sites are found along the coastal zone, so some of the contrast seen in temperature trends may be from geographic differences, rather than urban effects. In addition, the landscape surrounding the station may have changed with urbanization, and

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heated buildings or devices may have impacted the thermometer readings. Temperatures at airport weather stations may be influenced by radiant heat from the runways. Future data sets for this indicator may be refined to reflect a subset of select temperature monitoring sites that have been screened to have few confounding factors. Although new instruments have been developed, they were not calibrated with the equipment they have replaced. Fortunately, thermometers that have been used over the decades are deemed to be as reliable as current instruments. Historically, volunteers staff weather stations throughout the state. The volunteers select the time of day they wish to consistently record the maximum and minimum temperatures.

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Western Regional Climate Data Center, website at: www.wrcc.dri.edu

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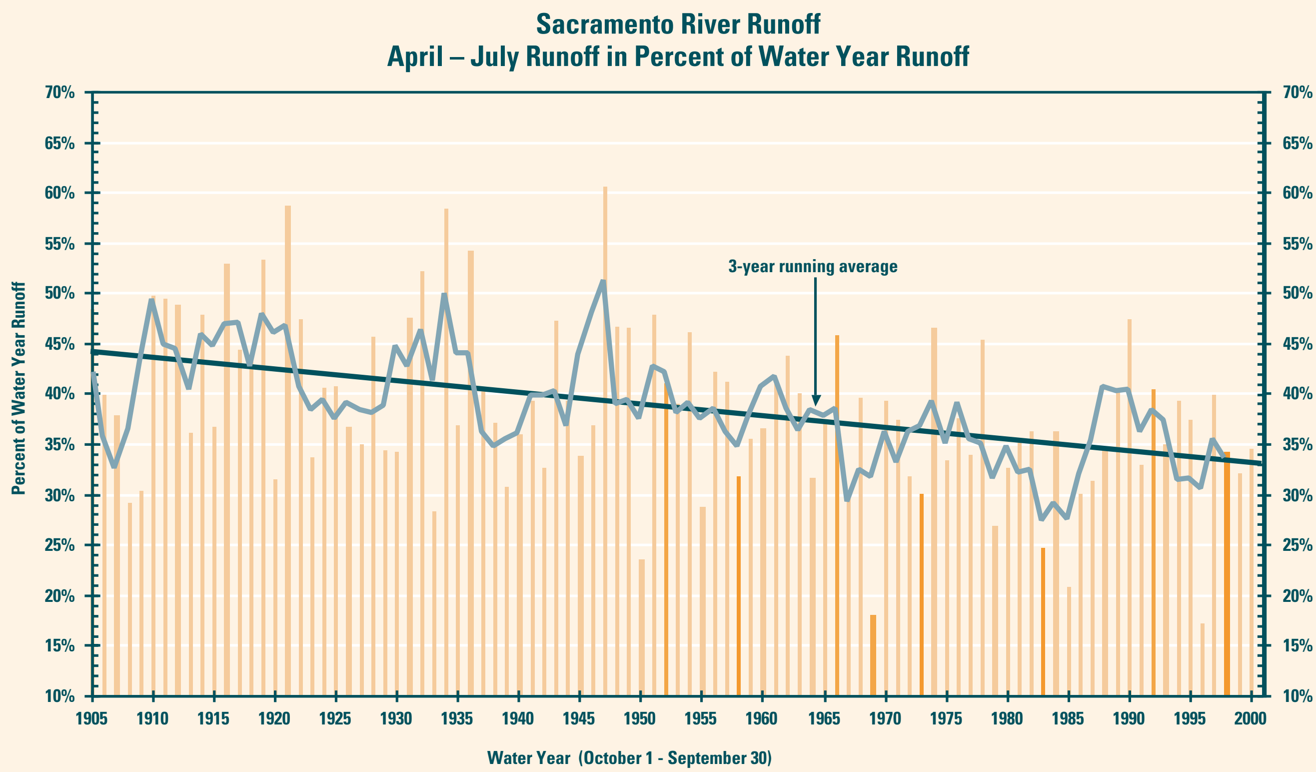
Annual Sierra Nevada Snowmelt Runoff

Spring runoff in California has declined over the past 95 years.

Type I

Level 3
Goal 4



Source: Department of Water Resources

Why is this indicator important?

The fraction of the annual stream discharge that occurs from spring and early summer snowmelt, computed as the ratio of April through July discharge to each water year's (October through September) annual total, provides a measure of temperature-related runoff patterns. Large accumulations of snow occur in the Sierra Nevada and southern Cascade Mountains from October to March. Each winter, at the high elevations, snow accumulates into a deep pack, preserving much of California's water supply in cold storage. Spring warming causes snowmelt runoff, mostly during April through July. If the winter temperatures are warm, more of the precipitation falls as rain instead of snow, and water directly flows from watersheds before the spring snowmelt. Other factors being equal, there is less buildup of snow pack; as a result, the volume of water from the spring runoff is diminished. Lower water volumes of the spring snowmelt runoff may indicate warmer winter temperatures or unusually warm springtime temperatures.

What is the indicator showing?

The percentage of annual runoff fraction during the spring snowmelt period of the Sacramento River has decreased by 12 percent since 1906.

A heavier rainfall burden rather than snow in the winter results in higher flood risks and reduced snow-related recreational opportunities in the mountains. Less spring runoff can reduce the amount of potential summer water available for the state's water needs and hydroelectric power production. Lower runoff volumes can also impact recreation opportunities, and impair cold water habitat for salmonid fishes (Maury Roos, 2000).

What factors influence this indicator?

The warming of global climate might increase evaporation rates, thereby potentially increasing precipitation and storms in the state. The yearly ratio of rain to snow depends on temperature, as does snow level elevations. The warmer the storm temperature, the higher the elevation at which snow falls and accumulates. Higher elevations of the snow line mean reduced snow pack and lower spring water yields.

Snowmelt and runoff volume data can be used to document changes in runoff patterns. These changes are likely due to increased air temperatures and climate changes. Other factors, such as the Northern Pacific Ocean oscillations and, possibly air pollution, probably contribute to the patterns observed.

During the 20th century, the fraction of annual unimpaired runoff that occurs from April to July, represented as a percentage of total water year runoff from the accumulated winter precipitation in the Sierra Nevada, has been decreasing. "Unimpaired" runoff refers to the amounts of water produced in a stream unaltered by upstream diversions, storage, or by export or import of water to or from other basins. This decreased runoff was especially evident after mid-century, when the water runoff has declined by about ten percent. Most of the change took place after 1950 and the recent two decades seem to indicate a flattening of the percentage decrease.

Technical Considerations:

Data Characteristics

The California Cooperative Snow Surveys Program of the California Department of Water Resources (DWR) collects the data. Runoff forecasts are made systematically, based on historical regression relationships between the volume of April through July runoff and the measured snow water content, precipitation, and runoff in the preceding months (Maury Roos, "Water Supply Forecasting", DWR, 1992).

Related snow pack information is used to predict how much spring runoff to expect for water supply purposes. Each spring, about 50 agencies, including the United States Geological Survey, pool their efforts in collecting snow data at about 300 snow courses throughout California. A snow course is a transect along which snow depth and water equivalent observations are made, usually at ten points. The snow courses are located throughout the state from the Kings River in the South to Surprise Valley in the North. Courses range in

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elevation from 4,350 feet in the Mokelumne River Basin to 11,450 feet in the San Joaquin River Basin.

Since the relationships of runoff to precipitation, snow, and other hydrologic variables are natural, it is preferable to work with natural or unimpaired runoff. The spring runoff is calculated purely from stream flow. These are the amounts of water produced in a stream unaltered by upstream diversions, storage, or by export or import of water to or from other basins. To get unimpaired runoff, measured flow amounts have to be adjusted to remove the effect of man-made works, such as reservoirs, diversions, or imports (Roos, 1992). The water supply forecasting procedures are based on multiple linear regression equations, which relate snow, precipitation, and previous runoff terms to April-July unimpaired runoff.

Major rivers in the forecasting program include the Sacramento, Feather, Yuba, American, San Joaquin, Merced, Tuolumne, Stanislaus, and Kings on the western slopes of the Sierra, and the Truckee, Walker, Carson and Owens on the eastern slopes. Spring runoff percentages have declined throughout much of the mountain range:

River Runoff	Percent Decline in the 20th Century
Sacramento	12
Truckee	15
San Joaquin	8
Kings	7
East Carson and West Walker	9

Strengths and Limitations of the Data

Data have been collected for almost one century for many monitoring sites. Stream flow data exist for most of the major Sierra Nevada watersheds because of California's dependence on their spring runoff for water resources and the extreme need for flood forecasting. The information represents spring rainfall, snowmelt, calculated depletions, and diversions, in part from other rivers and reservoirs. Raw data are collected through water flow monitoring procedures and used along with many other variables in a model, to calculate the unimpaired runoff of each watershed.

Over the years, instrumentation has changed and generally improved; some monitoring sites moved to different locations. The physical shape of the streambed can affect accuracy of flow measurements at monitoring sites, but most sites are quite stable.

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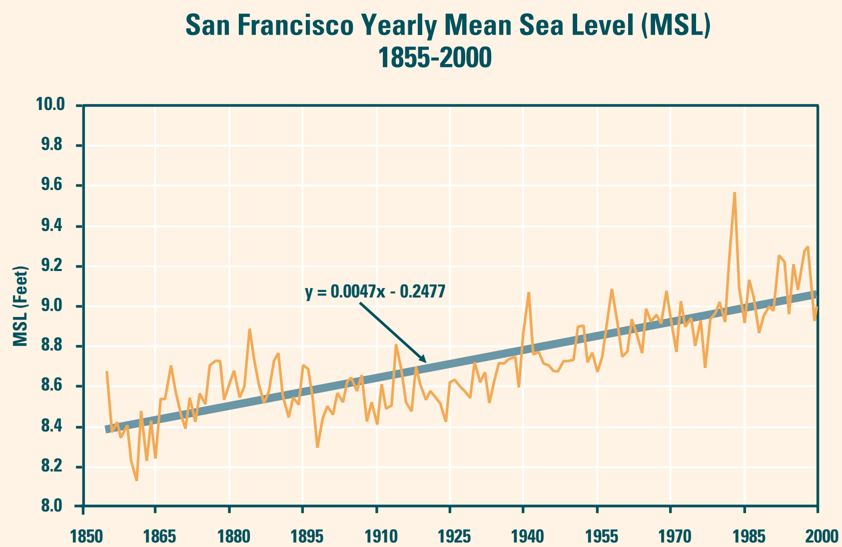
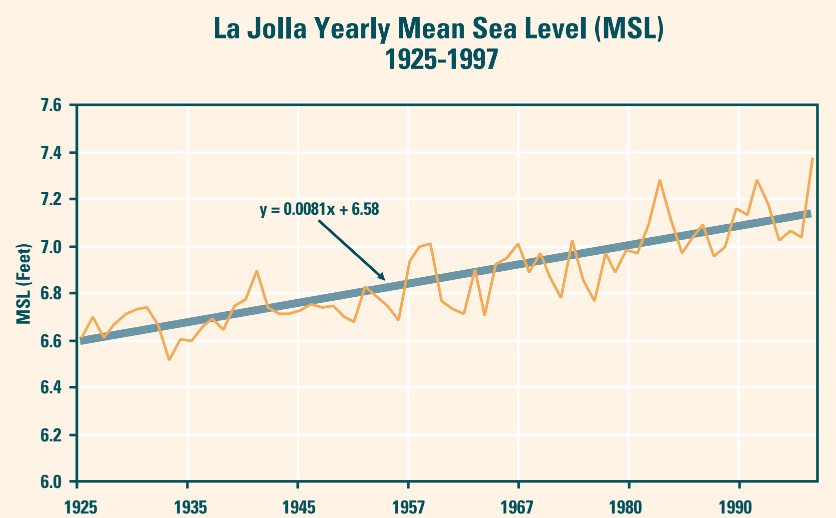
Type I

Level 4
Goal 4

Sea Level Rise in California

Sea levels have increased over the past century.





Source: National Ocean Service of NOAA

What is the indicator showing?

Sea levels have risen at two tide gauge locations along the California coast.

Why is this indicator important?

Sea level rise provides a physical measure of possible oceanic response to climate change. Average global sea level has risen between four to eight inches during the 20th century, approximately one-tenth of an inch each year. The indicator shows the rising trend in sea level measured at two California stations: San Francisco and in La Jolla. While sea level data from only two California stations are presented, long-term data from 10 of 11 California stations show increases in sea level. Hence, while the rates of increase vary, sea level is increasing almost everywhere in California (Flick, 1999).

The rise in global sea level is attributed to the thermal expansion of ocean water and the melting of mountain glaciers and ice sheets around the globe. At the current rate of melting, the seas could rise another foot over the next 50 years (IPCC, 2001). However, sea level rise is not a new phenomenon, having been a major natural component of coastal change throughout time. The concern is that with possibly increased global warming the rate of change may increase.

Sea level rise and storm surges could lead to flooding of low-lying areas, loss of coastal wetlands such as the San Francisco Bay Delta, erosion of cliffs and beaches, saltwater contamination of groundwater aquifers and drinking water, and impacts on roads, causeways, and bridges. California's hundreds of miles of scenic coastline contain ecologically fragile estuaries, expansive urban centers, and fisheries that could be impacted by future changes in sea level elevation.

What factors influence this indicator?

Along California's coast, sea level already has risen by three to eight inches over the last century (three inches at Los Angeles, five inches at San Francisco, and eight inches at San Diego), and it is likely to rise by another 13 to 19 inches by 2100 (U.S. EPA, 2001). Differences in sea level rise along the coast can occur because of local geological forces, such as land subsidence and plate tectonic activity.

The rise in sea level may be associated with increasing global temperatures. Based on results from modeling, warming of the ocean water will cause a greater volume of sea water because of thermal expansion. This is expected to contribute the largest share of sea level rise, followed by melting of mountain glaciers and ice caps (IPCC, 2001). There has been a widespread retreat of mountain glaciers in non-polar regions during the past 100 years. There is a trend for reduced Arctic sea-ice in the spring (IPCC, 2001).

The earth goes through cycles of warming and cooling, called ice ages, about every 100,000 years. The colder glacial cycles occur when the earth is in an oval elliptical orbit and farther from the sun. Because of the cooling, water from the oceans and precipitation forms ice sheets and glaciers. Much of the water is stored in the polar ice caps and in land bound glaciers. However, during the earth's shorter, circular orbit, it is closer to the sun, warms up, and water flows from melting glaciers to the oceans, driving up sea level. These warming interglacial periods last about 10,000 years. We are about two-thirds of the way through a warming trend now. During the last interglacial period, sea level rose about 20 feet above where it is today (U.S. EPA, 2001). Global warming studies predict that global sea level will rise at an accelerated rate, much beyond that seen in prehistoric "natural" cycles of warming and cooling evidenced by geologic data.

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Technical Considerations:

Data Characteristics

The San Francisco data are obtained from the Golden Gate tide gauge, and the La Jolla data from a gauge at the Scripps Institution of Oceanography pier. The San Francisco record begins in 1855 and represents the longest continuous time series of sea level in North America (Flick, 1998). The record at San Francisco shows a sea level rise of about 8.04 inches from 1855 to 2000, or 5.54 inches per century. This agrees with a much broader collection of tide gauge data that show that global average sea level rose between four to eight inches during the 20th century. The tide gauge record at La Jolla shows an increase in mean sea level of approximately 6.6 inches in the past 75 years, or looking back, perhaps 8.8 inches per century. Tide data from other California monitoring stations are posted at the web site of the National Ocean Service of the National Oceanic and Atmospheric Administration.

Monthly or yearly mean sea level statistics are derived by averaging near-continuous water level measurements from tide gauges. Sea level fluctuates at all time scales, but tide gauges remove the effects of waves and other fluctuations shorter than about 12 minutes. Sea levels change with tides, storms, currents, seasonal patterns of warming, and barometric pressure and wind.

Strengths and Limitations of the Data

Due to astronomical forces, such as the lunar cycle, it is difficult to isolate possible changes due to global warming in the sea level tidal record. Monthly mean sea levels tend to be highest in the fall and lowest in the spring, with differences of about 6 inches. Local warming or cooling resulting from offshore shifts in water masses and changes in wind-driven coastal circulation patterns also seasonally alter the average sea level by 8.4 inches (Flick, 1998). For day-to-day activities, the tidal range and elevations of the high and low tides are often far more important than the elevation of mean sea level. Shoreline damage due to wave energy is a factor of wave height at high tide and has a higher impact on the coast than mean sea level rise.

Geological forces such as subsidence, in which the land falls relative to sea level, and the influence of shifting tectonic plates complicate regional estimates of sea level rise. Much of the California coast is experiencing uplift due to tectonic forces. Mean sea level is measured at tide gauges with respect to a tide gauge benchmark on land, which traditionally was assumed to be stable. This only allows local changes to be observed relative to that benchmark. There are studies in progress that will study the feasibility of monitoring absolute changes in sea level on a global scale through the use of global positioning systems (GPS) satellite altimetry. The GPS may be useful to record vertical land movement at the tide gauge benchmark sites to correct for seismic activity and the earth's crustal movements.

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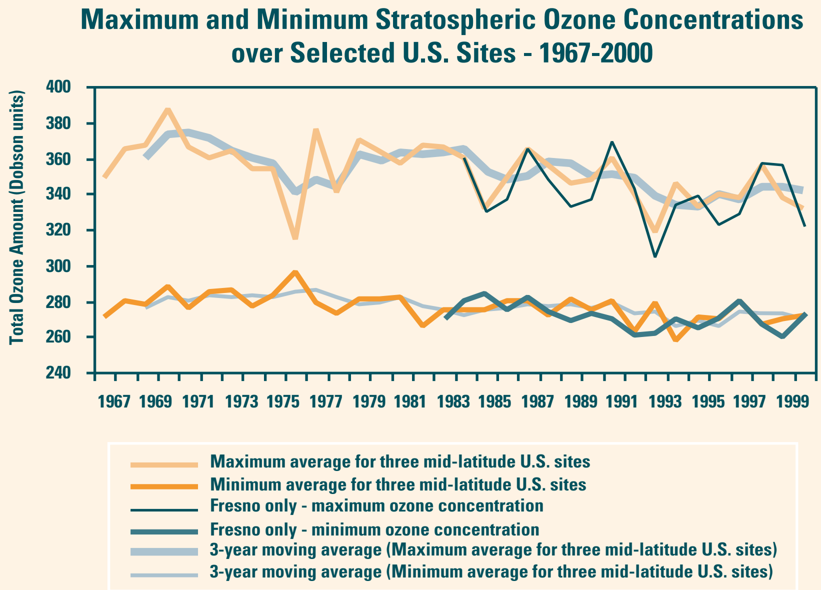
Stratospheric Ozone Depletion

Total stratospheric ozone generally decreased over the mid-latitudes of the Northern Hemisphere (including California and the continental U.S.) from 1979 to the early 1990s, but the downward trend has not continued in recent years.

Type I

Level 4
Goal 4



Source: Climate Monitoring & Diagnostics Laboratory

What is the indicator showing?

Stratospheric ozone monitoring sites located at mid-latitude regions in the Western Hemisphere have noted a gradual decline in stratospheric ozone levels of two to four percent per decade from 1979 to about 1993. The subset of monitoring sites located in the continental United States (in Colorado, Virginia, and Tennessee) and California (established in Fresno in 1983) generally reflects this overall trend. Natural seasonal fluctuations result in maximum and minimum ozone levels each year, reflected above as the months with the average maximum and minimum ozone levels. The three-year moving averages provide an easier means of perceiving trends. Since 1993, the overall rate of decline of stratospheric ozone for the Northern Hemisphere has not continued. While it remains to be seen whether this recent trend continues, it does correlate with the current stabilization of ozone-destroying chlorine and bromine levels in the stratosphere.

Why is this indicator important?

In the upper atmosphere 6 to 30 miles above the earth's surface, stratospheric ozone surrounds the earth and protects it from much of the harmful ultraviolet (UV) light rays that emanate from the sun. Through natural processes involving sunlight and oxygen, ozone is created and destroyed at a rate that produces a relatively stable level of stratospheric ozone. However, the increased presence of chlorine (Cl) and bromine (Br) in the stratosphere, originating primarily from chlorofluorocarbon (CFC) emissions at ground level, has resulted in an increased rate of stratospheric ozone destruction for the past two decades or more.

The degradation of the stratospheric ozone leads to higher levels of UV radiation reaching the Earth's surface. Exposure to excessive UV radiation is known to lead to increased incidences of skin cancers and eye cataracts, damage to crops and aquatic organisms, and deterioration of human-made materials (e.g., certain vinyl or plastic products). The average ozone loss across the globe totaled about 5 percent since the mid-1960s, with cumulative losses of about 10 percent in the winter and spring and a 5 percent loss in the summer and autumn over North America (U.S. EPA, 1996). In terms of how ozone depletion will affect humans, previous work has shown that when total ozone decreases, UV increases (U.S. EPA, 1996). The term “total ozone” includes both stratospheric and ground level ozone. A drop of 10 percent in total ozone concentrations increases UV-B radiation on the Earth’s surface by some 20 percent (WMO, 1995). Further work has shown that elevated surface UV levels in mid-to-high latitudes were observed in the Northern Hemisphere in 1992 and 1993, corresponding to the low stratospheric ozone levels for those years (U.S. EPA, 1996). However, the lack of long-term monitoring of surface UV levels and uncertainties introduced by clouds and ground-level pollutants, which can greatly affect the amount of UV rays reaching the ground, have not allowed the clear identification of a long-term trend in surface UV radiation.

What factors influence this indicator?

Under natural meteorological conditions, stratospheric ozone concentrations show seasonal variations, as can be inferred from the yearly maximum and minimum ozone levels shown in the graph. The amount of ozone over any one region in California can vary considerably in response to stratospheric winds. Large fluctuations can occur from day to day, and week to week, as well as season to season. However, global stratospheric ozone transport processes normally result in winter-spring maximums and summer-fall minimums over California.

When CFCs and other ozone destroying chemicals (e.g., carbon tetrachloride, methyl chloroform, methyl bromide, etc.) are released into the air, they eventually migrate into the stratosphere where the reaction with UV radiation releases the chlorine (Cl) and bromine (Br) atoms. Cl and Br can then act as catalysts, destroying ozone at a rate greater than it can be created through natural processes. The Cl and Br atoms from CFCs may remain in the stratosphere for decades, destroying many thousands of ozone molecules during their stratospheric life. Exposure to the extreme winter cold in the Polar Regions followed by seasonal warming result in an accelerated destruction of the protective ozone layer during early spring. Thus, stratospheric ozone depletion is greater over the Polar Regions relative to mid-latitude regions of the Northern Hemisphere. Due to colder winters in Antarctica (South Pole) compared to the Arctic region (North Pole), seasonal ozone depletion is greater over Antarctica and has resulted in severe seasonal depletion creating an “ozone hole”. The production and use of CFCs, used in refrigeration, air conditioning and other industrial processes, are gradually being phased out under the 1987 Montreal Protocol. Under the Clean Air Act Amendments of 1990, U.S. EPA phased out the production and use of CFCs in the United States completely on January 1, 1996. Production of hydrochlorofluorocarbons (HCFCs) and other compounds with considerably lower or no ozone depleting ability has essentially replaced CFCs. In the United States, production and use rates of HCFCs are increasing (OCED, 1998).

In the lower stratosphere, the amount of Cl and other ozone destroying chemicals reached peak values around 1997-98, but still remain at high levels. Thus far, this trend roughly correlates with the decreased rate of decline of ozone depletion over the mid-latitude regions of the Northern Hemisphere since the early 1990s. Recent studies predict that the current peaking levels of CFC's in the atmosphere should fall to pre-1980 levels by about 2050. However, any changes that occur needs to be examined in the context of changes in amounts of ozone depleting gases in the atmosphere and varying meteorological conditions. Continued monitoring and measurements are essential towards this end.

Technical considerations

Data Characteristics

Yearly maximum and minimum stratospheric ozone levels provide a simple method for showing the long-term trend in stratospheric ozone concentration, which has a natural fluctuation pattern from season-to-season.

The National Oceanic and Atmospheric Administration (NOAA) operates a 16-station global Dobson spectrophotometer network for total ozone trend studies. Four of these stations are located at mid-latitudes in the continental U.S. Weather conditions permitting, daily ozone measurements are collected. Each point on the graph represents either the highest average ozone level recorded for one month (usually in Spring), or the lowest average ozone level recorded in one month (usually in Fall).

Total ozone amounts are measured in Dobson Units. A positive correlation exists between the number of Dobson Units and the absorbance of UV radiation – the greater the number of Dobson Units, the greater the absorption of UV radiation. The definition of a Dobson Unit can be described like so: if all the ozone in a column of air over California were to be compressed to standard temperature and pressure (STP) (0 deg C and 1 atmosphere pressure) and spread out evenly over the area, it would form a slab approximately 3 mm thick. One Dobson Unit (DU) is defined to be 0.01 mm thickness at STP. Thus, the ozone layer over California is 300 DU.

Strengths and Limitations of the Data

Collection of ozone data from the Fresno station began in 1983. To better illustrate the ozone trend, averaged data from three other mid-latitude stations are shown going back to 1967. However, all four stations presented similar trends and concentrations in ozone levels and are representative of mid-latitude regions of the Northern Hemisphere, which includes California and much of the continental United States.

Factors in addition to the level of Cl and Br in the stratosphere may have an influence on stratospheric ozone levels. For example, unusually cold polar winters are known to greatly accelerate ozone destruction in the Polar Regions, and thus may subsequently affect mid-latitude ozone levels through mixing by stratospheric winds. Also, the volcanic eruption of Mt. Pinatubo appeared to cause a worldwide downward trend of total ozone during 1991-1992.

Consistent collection of ground level UV radiation data to corroborate ozone depletion findings has not been performed. Thus, the UV radiation exposure risk resulting from depletion of total ozone is unknown.

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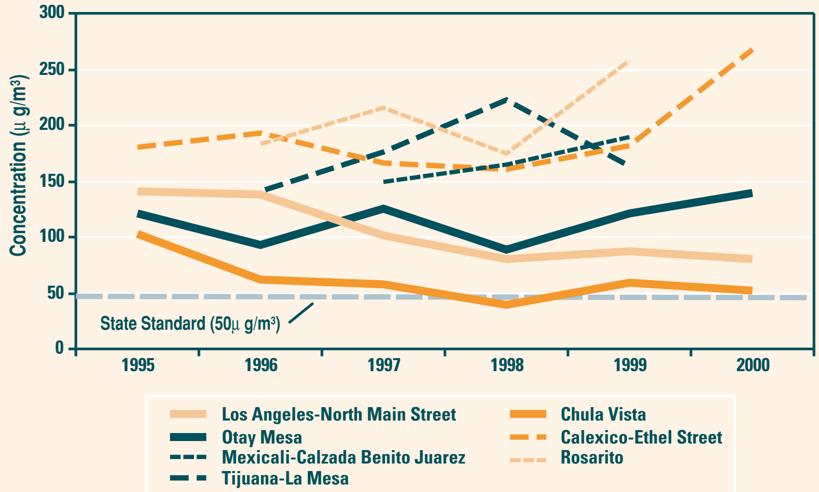
Air Pollutants At The California/Baja California, Mexico Border

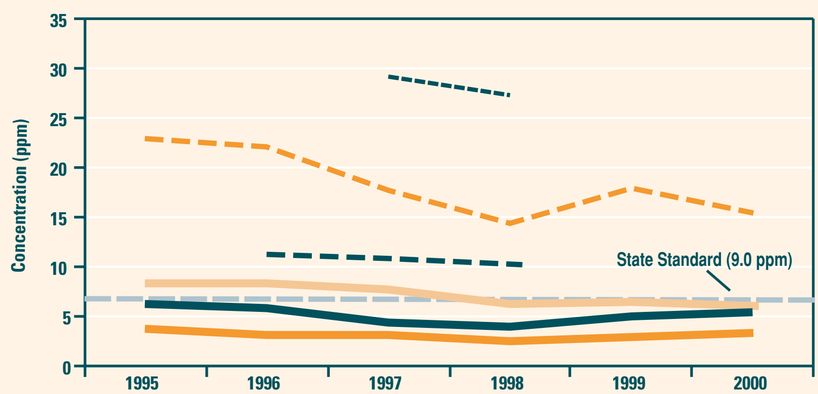
Peak concentrations of inhalable particulate matter (PM10), ozone, and carbon monoxide continue to exceed California air quality standards in the border region.

Type I
Level 4
Goal 1

Peak PM10 Concentrations
24-hour average



Peak Carbon Monoxide Concentrations
8-hour average



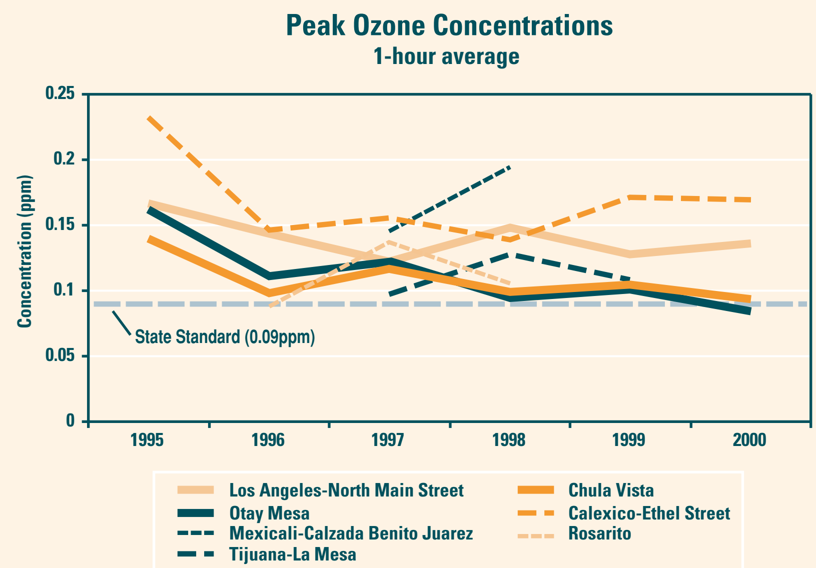
Source: California Air Resources Board

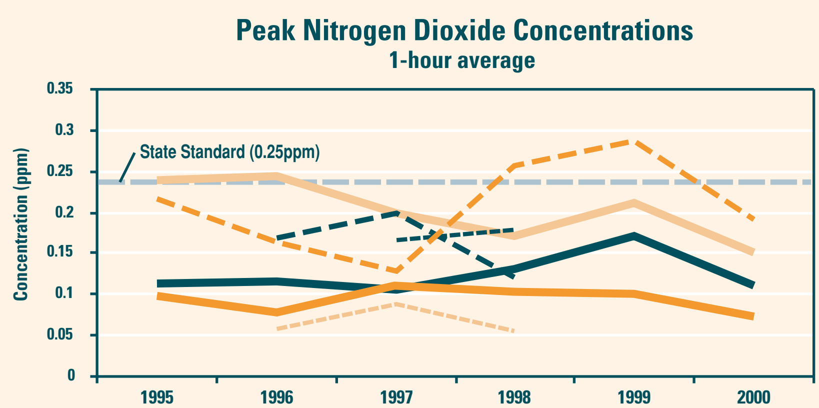
What are the indicators showing?

Cross-border air quality monitoring has been conducted in the San Diego/Tijuana region since 1995 and in Calexico/Mexicali since 1997. Data from monitoring stations at these cities show that concentrations of inhalable particulate matter (particulate matter 10 microns in diameter and less, or PM10) exceed the California State standard . Carbon monoxide concentrations exceed the state standard at Mexicali, Calexico, and Tijuana. Ozone peak 1-hour concentrations show exceedances of the state standard at all the stations in the border region with a downward trend for the California cities. The nitrogen dioxide (NO_2) standard was exceeded in Mexicali in 1998 and 1999, but all cities were in attainment in 2000. Data for one monitoring station in Los Angeles (located north of the border region) are presented to give a perspective to the air levels reported for the border communities. Monitoring data are not available for certain years at some sites.

Why is this indicator important?

The California/Baja California, Mexico border region is defined as the area within 100 kilometers (62 miles) of either side of the international border. The larger cities within the border region lie within common air basins, hence, both countries share responsibility for the impacts of air pollution. San Diego (Chula Vista and Otay-Mesa air monitors) on the coastal California side, and Tijuana and Rosarito on the Mexican side can be considered sister cities. Likewise, on





Source: California Air Resources Board

the eastern side of the state, Calexico (in California) and Mexicali (in Mexico) can be considered twin cities and actually are separated by only a city street. Attainment of air quality standards in the region requires the reduction of air pollutants on both sides of the border. The indicators will track trends in air quality in the border region in the face of growing urban populations and further industrialization.

What factors influence this indicator?

The San Diego-Tijuana area is situated along the Pacific Coast and is strongly influenced by ocean breezes. The majority of the time, daytime winds are from the west and nighttime winds are from the east, with slight variations. Daytime winds are usually much stronger than those at night and tend to blow the air pollutants from the urban areas inland.

Carbon Monoxide Count of Days Exceeding Statewide 8 Hour Standard (9.0 ppm)						
Station	1995	1996	1997	1998	1999	2000
Los Angeles-North Main Street	0	0	0	0	0	0
Chula Vista	0	0	0	0	0	0
Calexico-Ethel Street	17	11	13	10	13	7
Mexicali-Calzada Benito Juarez			42	59		
Otay Mesa	0	0	0	0	0	0
Rosarito		0	0	0		
Tijuana-La Mesa		3	4	1		

PM10 Calculated Days Exceeding State 24 Hour Standard (50µg/m³)					
Station	1995	1996	1997	1998	1999
Los Angeles-North Main Street	84	66	90	66	114
Chula Vista	30	12	12	0	12
Calexico-Ethel Street	201	246	294	234	264
Mexicali-Calzada Benito Juarez			120	108	162
Otay Mesa	114	90	126	108	126
Rosarito		132	276	210	276
Tijuana-La Mesa		189	252	189	204

Ozone-Count of Days Exceeding State 1 Hour Standard (0.09 ppm)					
Station	1995	1996	1997	1998	1999
Los Angeles-North Main Street	38	24	6	17	13
Chula Vista	7	1	10	2	4
Calexico-Ethel Street	38	44	24	25	38
Mexicali-Calzada Benito Juarez			20	18	
Otay Mesa	17	6	7	0	1
Rosarito		0	4	2	
Tijuana-La Mesa		1	15	2	

Source: California Air Resources Board

Climatic conditions in Calexico and Mexicali are characterized by winds that blow most often from the west and northwest. However, during the summer months the direction shifts dramatically and the wind blows from the southeast.

PM10, ozone, and carbon monoxide can exacerbate respiratory problems, including asthma and decreased lung function. Air standards for these pollutants are intended to protect human health. Ozone is formed by the photochemical reaction of sunlight with certain air pollutants, such as volatile organic compounds and nitrogen oxides. These pollutants are emitted from motor vehicles as well as industrial sources.

PM10 particles originate from mechanical activities, windblown dust, combustion sources, and chemical reactions in the atmosphere. Field studies have shown that the major component of PM10 in the Calexico/Mexicali region is directly emitted dust, such as from unpaved roads.

High carbon monoxide concentrations can be seen on the Mexican side of the border because the vehicle fleet consists primarily of older cars. Due to lack of maintenance and the absence of requirements for smog check inspections, the emission controls of these vehicles are often deteriorated, resulting in greater carbon monoxide emissions. Although California reformulated gasoline is widely used in the Mexican border region, the use of Mexican fuels may increase tailpipe emissions.

Oxides of nitrogen (NOx) contribute to the formation of ozone. The main sources of NOx are motor vehicles and industrial combustors. New power utilities are being constructed in Rosarito, Tijuana and Mexicali and it is expected that emissions of NOx will increase as a result.

The air quality measurements at an air monitoring site are representative of the levels of air pollutants in the general neighborhood of the monitoring station. Thus, the Otay-Mesa station, located among the complex of buildings that make up the Otay-Mesa border crossing, provides an indication of ozone levels in the southern tier of San Diego County, as well as the northernmost part of the city of Tijuana.

The monitoring network in the border region has increased significantly in the past few years. Increases in peak concentrations during this period may be misleading since additional monitors (in additional locations) provide more opportunities to measure poor air quality. Confidence in this indicator should improve as more data are accumulated.

Technical Considerations:

Data Characteristics

The data presented are representative in general of only one air monitoring station at each city. However, most of the areas have several monitoring stations. All the data presented meets quality assurance standards of the California Air Resources Board and the U.S. Environmental Protection Agency for air monitoring. Monitoring data were not available for certain years at some sites.

Strengths and Limitations of the Data

The ambient air concentrations of these pollutants were accurately measured and recorded. Information from each individual station is indicative of pollution levels in the general neighborhood of the monitoring station. However, data from multiple stations are needed to obtain a comprehensive view of the air quality in that region.

Although the discussion has focused on the criteria pollutants (PM10, carbon monoxide, ozone, and NO_2), toxic air contaminants (TACs) are also measured in the border region. Common TACs are solvents, metals, and hydrocarbons emitted from the combustion of petroleum products and manufacturing processes. Typical TAC emission sources may be service stations, dry cleaners, electroplating industries, electronics manufacturing facilities, and paint shops. TACs are measured at Chula Vista, El Cajon, Calexico, Mexicali and Rosarito. The TAC monitoring data can be viewed at: www.arb.ca.gov/aqd/almanac01/chap601.htm.

Reference:
California Air Resources Board,
California Air Quality Data,
www.arb.ca.gov/aqd/aqd.htm

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Ballast Water Program

Type III

Ballast water discharged from United States and foreign vessels visiting California ports has been responsible for the introduction of non-indigenous aquatic species (NAS) into the state's waters. As world trade and travel have increased, the invasion rate of new aquatic species has grown exponentially (Cohen, 1998). After ships discharge their cargo, they take on ballast water from the local port to provide stability before going to sea again. Often the ballast waters and sediments are rich in organisms such as viruses, bacteria, protozoa, seaweed, algae, fungi, plants, and fish, which are then transported and released in other areas of the world. Some NAS have displaced native plants and marine life, and have caused economic, human and ecological health impacts (United States Congress, 1993).

To prevent new introductions of NAS into the state, the California Ballast Water Management Act of 1999 (Act) (Public Resources Code Section 71200) requires vessels to exchange ballast water mid-ocean to reduce the density of organisms in ballast tanks. The California State Lands Commission (CSLC) enforces the requirements of the Act through an active inspection program, which targets approximately 25 percent of qualifying ship arrivals. Ballast water from vessels is analyzed for saline content to verify that it originated from mid-ocean sources and is not brackish from coastal ports. Ninety-two percent of inspected vessels were found to be in compliance with the Act during the first year of the program.

Mid-ocean ballast exchange reduces the amount of foreign coastal marine organisms deposited in California waters, but it may only eliminate 55 to 67 percent of the original species entrained in the ballast water due to tank design and organisms that reside in bottom sediment (Greenman, 1997). In the summer of 2001, the Port of Oakland and Smithsonian Environmental Research Center initiated a study on the effectiveness of ballast exchange in reducing the introduction of NAS. As part of the study, an inventory of hull and ballast water organisms on arriving ships will be created. Additionally, the CSLC, with funding from the United States Fish and Wildlife Service and the Port of Oakland, will retrofit two volunteer commercial vessels in the fall of 2001 with ballast water treatment systems. The State Water Resources Control Board will evaluate the effectiveness of these systems, in collaboration with the CSLC, United States Coast Guard and Smithsonian Environmental Research Center.

Also as part of the mandates of the Act, the Office of Spill Prevention and Response of the California Department of Fish and Game is conducting an inventory of NAS populations in coastal and estuarine waters to establish indigenous baseline populations. Reports required under the Act are due to the Legislature in December 2002. The information presented in these reports may be used to craft a new, long-term program, which could be adopted before the current law expires on January 1, 2004.

The Ballast Water Program may eventually include biota evaluations of selected species and, coupled with saline inspections, provide an indicator of NAS introductions and effective treatment measures.

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Environmental Exposure Impacts Upon Human Health

Introduction

Californians are concerned about the harmful effects of environmental pollutants on their health. Sharing this recognition that exposures to environmental contaminants have the potential to adversely impact human health, Cal/EPA and the Department of Health Services seek to reduce or eliminate potentially harmful exposures to hazardous chemicals in the environment.

It is not always easy to determine when environmental pollutants produce disease. Disease occurrence is a product of many factors that influence progression from wellness to disease, beginning with imperceptible or subtle changes in normal biochemical activity, followed by measurable impairments in body function, the obvious appearance of disease, and ultimately death. Specific susceptibilities to particular illnesses may be inherited or acquired. Some individuals may be predisposed to specific diseases because of certain genes inherited from their parents. For example, over 40 percent of all individuals with retinoblastomas (a rare tumor affecting the retina) have inherited the susceptibility for that cancer (Paulino, 1998). Colorectal, breast, and ovarian cancers, some forms of acute and chronic leukemia, and other forms of cancer have been shown to run in families due to hereditary influences. Disease susceptibility is also strongly influenced by aging, and by many factors including infections, exposure to hazardous environmental chemicals, and certain lifestyle behaviors. Our understanding of cancer risk factors remains incomplete, however, lifestyle factors alone, particularly smoking, diet, and lack of exercise may contribute to a majority of known cancer risks (Harvard Center for Cancer Prevention, 1996).

Conversely, certain beneficial factors can promote health, counteracting the influences of detrimental factors. Disease progression can be slowed by healthy lifestyle choices such as good nutrition, routine exercise, avoidance of tobacco use, positive social environment, and medical treatment. These factors can reverse or delay the disease process, improving the quality of, and prolonging life. Largely due to sanitary measures, the adoption of healthier lifestyles and improvements in the quality of medical care, there have been steady declines in infant mortality rates and increases in life expectancy (see *Infant Mortality* and *Life Expectancy* in the "Background Indicators" section).

In some instances, the predominant factor in human health can be exposure to environmental pollutants. A number of tragic examples clearly demonstrate a causal relationship between environmental pollutants and acute or chronic disease. Severe

Indicators of Environmental Exposure Impacts on Human Health

Human body concentrations of toxic chemicals

Surveillance of persistent organic pollutants in body tissues and fluids

Concentrations of persistent organic pollutants in human milk (Type III)

Lead in children and adults

Elevated blood lead levels in children (Type II)

Mercury in children and adults

Mercury levels in blood and other tissues (Type III)

birth defects occurred among a large number of infants born to women who consumed seafood contaminated with methylmercury caught from Minamata Bay, Japan. In Libby, Montana, many workers, their families, and local residents developed asbestosis and mesothelioma following exposures to asbestos and asbestos-like minerals from vermiculite mining activities. Finally, the widespread use of lead-based products, including gasoline and paint, until the 1970s caused thousands of children to suffer from severe lead poisoning, while many more suffered from subtle lifelong neurotoxic effects before these products were banned. Although much of the toxic effects of lead had been known for centuries, the public was largely uninformed about the potential devastating effects that these lead-containing products would have on children.

While large or unusual exposures to environmental contaminants can result in detectable increases in the numbers of disease cases in a population, disease from smaller or limited exposures are often not detectable. Sometimes environmentally-caused illnesses are subtle, or occur many years after the exposure. In addition, the health influences of factors other than environmental exposures (including genetics, diet, smoking and other lifestyle choices), or illnesses unrelated to the environmental exposure make it hard to distinguish to what extent environmental pollutants have contributed toward observed diseases.

How does Cal/EPA protect public health?

Protecting the public health from exposures to harmful environmental contaminants involves a process consisting of two phases: risk assessment and risk management. In the risk assessment phase, the likelihood of adverse health effects resulting from human exposures to environmental contaminants is evaluated. In the risk management phase, regulatory standards or criteria are developed and implemented to manage or eliminate harmful exposures to hazardous chemicals. For example, Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA) conducts risk assessments to develop human health protective guidelines for contaminants in drinking water (called public health goals); the Department of Health Services then considers these guidelines in risk management to promulgate regulatory standards (called maximum contaminant levels) to ensure the safety of drinking water.

Human health protection is often the underlying basis for many environmental regulations. Over the years, these regulations have led to significant reductions in the levels of contaminants in the environment as well as the prevention of further contamination. Table I is a list of the environmental indicators discussed in other sections of this chapter, which reflect and track the extent to which regulatory standards are met. These indicators provide an indirect measure of how well the public is protected from environmental contaminants.

What indicators are presented in this section?

The issues and indicators in this section focus on characterizing the impacts of environmental contaminants on human health. The discussions provide an overview of the state of knowledge regarding the association among exposures to environmental pollutants, concentrations of contaminants in the body (also known as "body burdens"), and diseases associated with exposures to environmental contaminants.

Tracking chemical body burdens has been found to aid in determining which individuals are at risk for disease, preventing the occurrence of disease, and determining the sources of exposure. For example, the detection and monitoring of blood lead levels in children is used to identify children in need of treatment to prevent lead poisoning. These data are valuable in developing effective measures to identify and reduce sources of lead in the environment.

This section broadly discusses several disease categories as issues of general interest associated with environmental contaminants. These categories are cancer, respiratory disease, and reproductive effects. Because of the lack of data as well as the complexity of the interactions among the various factors that produce disease, no indicators are proposed for this category. Rather, continuing or enhancing disease surveillance will be useful in understanding trends and providing information on causation.

Surveillance systems that track body burdens of toxic contaminants of concern and the incidence of environmentally-related diseases represent effective tools for understanding how body burdens or human diseases are influenced by environmental exposures. Based on information provided by surveillance systems, Cal/EPA can better formulate informed responses to environmental challenges.

Environmental Indicators Related to Public Health Protection
Air Quality
Days with unhealthy levels of ozone pollution
Peak 1-hour ozone concentration
Exposure to unhealthy ozone levels in the South Coast air basin
Emissions of ozone precursors (VOC + NOx)
Days with unhealthy levels of inhalable particulate matter (PM10)
Peak 24-hour PM10 concentration
Annual PM10 concentration
Total primary and precursor PM10 emissions
Days with unhealthy levels of carbon monoxide
Peak 8-hour carbon monoxide concentration
Carbon monoxide emissions
Total emissions of toxic air contaminants (TACs)
Community-based cancer risk from exposure to TACs
Cumulative exposure to TACs that may pose chronic or acute health risks
Indoor exposure to formaldehyde
Household exposure of children to environmental tobacco smoke (ETS)
Water
Drinking water supplies exceeding maximum contaminant levels
Total open leaking underground fuel tanks (LUFTs) sites
Groundwater contaminant plumes- Extent
Contaminant release sites
Coastal beach availability- Extent of coastal beaches posted or closed
Aquatic life and swimming uses assessed in 2000
Fish advisories - coastal waters
Fish advisories – inland waters
Bacterial concentrations in commercial shellfish growing waters
Land, Waste and Materials Management
Soil cleanup
Contaminated sites
Pesticides
Number of detections of pesticides identified as toxic air contaminants and the percent that exceeds numerical health standards each year
Area with pesticides detected in well water
Simazine and breakdown products in a monitoring network of 70 wells in Fresno and Tulare Counties
Pesticide detections in surface water and the percent that exceeds water quality standards
Percent of produce with illegal pesticide residues
Pesticide use volumes and acres treated, by toxicological and environmental impact categories
Number of growers adopting reduced-risk pest management systems and the percent reduction in use of high risk-pesticides (based on Alliance grant targets)
Number of reported occupational illnesses and injuries associated with pesticide exposure
Transboundary
Air pollutants at the California/Baja California, Mexico Border

Issue 1: Human Body Concentrations of Toxic Chemicals

Certain toxic chemicals, although present in low concentrations in the environment, may accumulate in human tissue because they resist environmental or biological degradation. These chemicals may pose an increased health risk as their tissue concentrations increase. For these chemicals, efforts are focused on avoiding and reducing exposures as much as technically feasible, even when adverse health effects are unknown. However, it is not always possible to know where exposures are coming from. Tracking the concentrations of these chemicals in the body (i.e., "body burden" levels) by a sustained, routine biological tissue monitoring system may yield valuable information on potential sources of environmental contaminants.

Indicator

Concentrations of persistent organic pollutants in human milk (Type III)

Sub-issue 1.1: Surveillance of persistent organic pollutants in body tissues and fluids

The persistent organic pollutants (POPs) are a large class of compounds that include polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), polychlorinated dioxins and furans, and certain pesticides, such as DDT, aldrin or dieldrin. These chemicals can enter the body through many exposure pathways from environmental media containing these chemicals, including air, food and water. Once in the body, these compounds tend to reside in fatty tissues where they persist until they are mobilized by various conditions. During pregnancy, these chemicals are carried from body fat by the blood through the placenta to the fetus. They can be ingested in breast milk by a nursing child or mobilized during weight loss.

Exposures to these compounds are of concern because they are known to affect certain hormonal pathways and some are associated with detrimental health effects. For example, some of the POPs are either known or suspected endocrine disruptors or carcinogens. No routine, ongoing surveillance system exists to monitor POPs in human tissues. The establishment of such a surveillance system for breast milk, fat tissues, and other systems would be beneficial (USEPA, 1998).

Indicator

Elevated blood levels in children (Type II)

Sub-issue 1.2: Lead in children and adults

Lead is a neurotoxin that impairs cognitive function and physical development, particularly in young children. For more than a decade, inorganic lead exposure to young children has been the major pediatric environmental health concern, particularly of poor children living in old, substandard housing where lead-based paint is often in a deteriorating condition. Blood lead levels greater than 10 micrograms per deciliter (µg/dL) in children are associated with lower intelligence and reading ability, learning disabilities, impaired hearing, reduced attention spans, and many other cognitive and physical problems. Subtle neurological and biochemical effects at levels lower than 10 µg/dL have been reported in the scientific literature. At this point, no threshold blood level concentration, below which no effect is expected to occur, has been determined. Adults exposed to high levels of lead, typically through occupational exposures, may have kidney toxicity, anemia, and nervous system disorders.

Historically, millions of tons of lead have been used in a wide array of consumer products in the United States. Because lead is an element, it will not degrade and will remain in the environment where it is released. With interventions, such as elimination of lead in gasoline and paint, excellent progress has been made in reducing the average blood lead levels in the overall population. Data from the Centers for Disease Control (CDC)'s Third National Health and Nutrition Examination Survey, Phase 2 (1991-1994) and the 1999 update showed that average blood lead levels decreased by approximately 80 percent since the 1970's (CDC, 2000). During the years 1976-1980 to the period of 1988-1991, the geometric mean of blood lead values declined from 12.8 μg/dL to 2.9 μg/dL. The levels further declined during the period of 1991-1994 to a geometric mean of 2.3 μg/dL. This survey also identified elevated blood lead levels in low-income children, children in urban areas and those living in older housing. Lead in deteriorating paint in housing constructed prior to the banning of lead in paint, soils contaminated with lead paint or deposits of lead from past gasoline emissions, and other sources continue to present possible sources of lead exposures. As older housing is renovated, lead exposure from this source should decrease. Nationally, children's blood lead levels have continued to decline in the 1990s (CDC, 2000).

Each year dozens of adults are poisoned with lead, primarily from occupational exposures. This is a particular problem because of potential adverse reproductive effects in males and females, as well as a substantial hazard to the developing fetus. Blood lead levels of adult workers are reported only when they exceed 25 μg/dL.

Sub-issue 1.3: Mercury in children and adults

Mercury and its compounds in the environment are derived from both natural sources and from human activity. In California, large amounts of mercury were released during mining for either mercury or gold ore into streams and lakes over the last two centuries, although relatively small concentrations of mercury were always present in the waters. Mercury poses a particular public health problem when it is discharged into aquatic bodies where the inorganic mercury is converted by microorganisms to the much more toxic form, methylmercury. When methylmercury contaminates the food chain, it biomagnifies in some aquatic organisms including fish, thereby posing a potential health hazard when ingested by humans.

Indicator

Mercury levels in blood and other tissues (Type III)

For the general population, the principal exposure pathways for mercury are inhalation of airborne mercury from dental amalgams and ingestion of fish (fresh water and marine) and other seafood containing methylmercury.
At higher exposure levels in adults, mercury may adversely affect the kidneys

and the immune, neurological, respiratory, cardiovascular, gastrointestinal, and hematological systems. The developing nervous system is especially sensitive to the toxic effects of low-level mercury exposure. Methyl mercury will cause birth defects or fetal death when pregnant women ingest sufficient quantities of methyl mercury (USEPA, 2001).

Issue 2: Environmentally Associated Diseases and Conditions

Environmental exposures to chemicals have been associated with certain human diseases. These effects have been found by observation or surveillance of unusual patterns, including new occurrences, of diseases. The effects of environmental pollutants may not always be detected by surveillance system. Nevertheless in the past, such surveillance had led to effective efforts to protect against harmful exposures to environmental pollutants, and to an understanding of the relationship between exposures to environmental chemicals and disease.

Sub-issue 2.1. Cancer

Cancer is a group of diseases which is recognized to be the second leading cause of death for Californians (see "Background Indicators" section). Generally, it is recognized that the exposure to environmental pollutants contributes less to the overall population cancer risk than other factors (Melse and deHollander; 2001; Doll, 1999). Smoking, diet, inactivity, and obesity have been identified as major cancer risk factors, and may account for about two-thirds of all cancer deaths (Harvard Center for Cancer Prevention, 1996). In addition to these major factors, other known contributing factors include alcohol consumption, viruses, genetics, radiation, and prescription drugs. Given the multiple factors that contribute to the risk of cancer, the long latency times between exposure to the onset of cancer, and the low levels at which chemicals usually occur in the ambient environment, associating cancer with specific environmental exposures becomes difficult.

Cancer is predominantly an adult disease increasing in incidence with age. Childhood cancers are generally rare, occurring at a rate of 15.2 cases per 100,000 U.S. children for 1998. By contrast, overall cancer incidence rate for all ages in the U.S. is 400.5 cases per 100,000. (SEER, 2001). For the past 25 years, the national childhood cancer incidence rate has remained generally stable. From the period of 1988 to 1994, the childhood cancer incidence rates in California are similar to the national rates (CCR, 1999). Childhood cancer is a concern because of the severity of the illness, the potential for delayed development, and premature deaths. Fortunately, successful treatment of childhood cancers has dramatically decreased mortality, to about half the death rate since 1973 (CCR, 1999).

As with adult cancer cases, childhood cancers can be the result of many factors. According to the 1999 report, "National Cancer Institute Research on Causes of Cancers in Children" (NCI, 1999) there are very few known causes of cancer in children. Those that have been identified to date include Down's syndrome, other specific chromosomal and genetic abnormalities, and treatment with radiation or chemotherapy. These causes are thought to contribute to only a small proportion of the cancers in children. Some research in this area suggests that exposure to certain environmental toxicants early in life may be linked to the development of certain childhood cancers.

Identifying and examining potential links between environmental agents and cancer are ongoing. Evidence of the link between environmental agents and cancer generally requires exposures at levels many times higher than those expected to occur in the ambient environment, such as those observed in occupational settings or from certain therapeutic drugs used to treat diseases, including cancer itself. Complicating this picture is the fact that people are exposed to many other substances that may affect the risk of cancer. The continuing efforts by the California Cancer Registry and California Department of Health Services to monitor detailed data on cancer incidence, mortality, and survival will contribute to the understanding of the causes and mechanisms of cancer (see www.ccrcal.org).

Sub-issue 2.2: Respiratory disease

Environmental pollutants are associated with increased acute respiratory disease morbidity; aggravation of asthma; increased prevalence of respiratory symptoms in children including prolonging infectious episodes; and decreasing lung function in children.

In particular, asthma is one of the most serious chronic respiratory diseases both in this country and around the world. For many years, the number of new cases has been increasing, particularly among children and adolescents (see asthma indicators in the "Background Indicators" section). It has been suggested that environmental factors, including exposure to certain air pollutants, are contributors to these increases. Yet, trends in the ambient levels of the most troublesome air pollutants in California, ozone and particulate matter, have been proceeding in the opposite direction or have remained stable, relative to the trends reported for asthma. Ozone levels in large California cities have been declining for many years, while particulate matter levels have had moderate declines or have been relatively constant. To begin to understand this dilemma, there are two fundamental, but separate, issues with regard to asthma and environmental factors that need to be considered. These are: (1) factors leading to the development or onset of asthma, particularly in children; and, (2) causes of aggravation, or exacerbation, of pre-existing asthma symptoms.

The environmental factors involved in the onset of asthma are complex and incompletely understood. However, many researchers suspect that the rate of asthma development among the population is increasing, resulting in more asthmatic attacks due to poor air quality and other factors, even though overall levels of air pollutants have declined. Ozone exposure has been implicated in the development of asthma, but it has become apparent that other more important factors may contribute to the onset of this disease. Such factors include genetics, exposure to allergens (such as those from dust mites and cockroaches) and indoor air quality pollution (such as respiratory viruses and environmental tobacco smoke).

In contrast, a number of air pollution studies in California (Koren, 1995) and other states have noted increased asthma hospital admissions or emergency visits associated with high levels of outdoor air pollutants in the regional air. California will soon require emergency room visits as reportable data (OSHPD, 2001), providing a possible means for tracking emergency room asthma visits. However, due to considerable changes in health care management, simply tracking asthma-related emergency room visits would not be a reliable indicator of poor air quality days. Successful asthma management has led to the decrease in the number of acute attacks requiring emergency room visits. Furthermore, very specialized expertise is needed to assess asthma-related emergency room visits and to track the history of the patient to identify exposures to other pollutants and allergens unrelated to outdoor air pollutants.

Sub-issue 2.3: Reproductive and developmental health effects

Various factors have long been known to influence adverse reproductive and developmental health outcomes apart from heredity. Since the 1940s, it has been known that mothers infected with rubella had a higher risk of losing their offspring, or of having their offspring affected by blindness and deafness. Later the drug thalidomide was shown to cause an increase in malformed fetuses among pregnant women taking that drug to reduce nausea. Recently, it has been shown that folic acid taken as a dietary supplement by pregnant women can reduce the incidence of spinal cord and brain birth defects.

In addition to birth defects, chemicals such as mercury can also cause fetal loss or miscarriages from prenatal exposure. To complicate the picture, there are a great variety of defects and disorders that are not obvious or diagnosed until later in life, including learning deficiencies or neurological impairments.

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As with cancer and respiratory disease, development and reproductive effects are influenced by many factors, and the degree to which environmental pollutants contribute to these outcomes is not thoroughly understood. The effects of chemicals on the overall rates of birth defects or reproductive outcomes are difficult to address, unless the effect is a rare defect and highly associated with the agent, and is rare. For example, thalidomide was identified as a causative agent when there was a high incidence of a very rare birth defect. Surveillance of birth defects (conducted by the California Birth Defects Monitoring Program, www.cbdmp.org) will play an important role in understanding the causes of birth defects and reproductive effects.

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Type II

Elevated Blood Lead Levels in Children

Childhood lead poisoning is the most common environmental health problem for children in the United States. It is usually silent, detected only when a child has a positive blood lead screening test. Left undetected, lead exposure causes lowered IQ, learning disabilities, attention deficit disorder, and other problems associated with the nervous system. In the long term, elevated blood lead levels may result in an increased likelihood for school failure and lower lifetime earnings potential.

Most lead exposure results from the presence of lead-based paint in older residential housing. Children are exposed when the paint is peeling, or is disturbed during renovations. Dust and soil in and around older housing can also be contaminated. Therefore, children in lower income families are at a higher risk of lead poisoning because they are more likely to live or spend time in old substandard housing. Not as commonly, children may be exposed to other sources of lead, including the use of certain ethnic remedies and cosmetics, imported lead-contaminated food products, and traditional ceramic cooking ware.

The federal Centers for Disease Control and Prevention (CDC) currently defines "elevated blood lead levels" as 10 micrograms per deciliter (µg/dL) or higher. New California regulations require clinicians to screen children for elevated blood lead levels at 12 and 24 months of age if the child receives assistance from a publicly funded program such as Medi-Cal, the Women, Infants and Children Program (WIC), or the Child Health and Disability Prevention Program, or if the child lives in a house built prior to 1978 that has chipped or peeling paint or that has recently been renovated. At present, only two laboratories report all childhood blood lead levels to the Childhood Lead Poisoning Prevention Branch of the Department of Health Services (DHS). Several other large laboratories around the state will begin electronic reporting of all blood lead levels over the coming year. As a result, data from more sites are expected to be available to estimate the prevalence of elevated blood lead levels among children in other parts of California.

As California's aging housing stock containing lead-based paint is remediated, it is anticipated that there will be a continued trend in decreasing blood lead concentrations.

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Concentrations of Persistent Organic Pollutants in Human Milk

Type III

The persistent organic pollutants (POPs) are an important class of compounds, which include polychlorinated biphenyls, polybrominated diphenyl ethers, polychlorinated dioxins and furans, and certain pesticides. These compounds were used in a variety of products and have been distributed worldwide. POPs resist environmental degradation and persist in the human body. They have known biologic activity; that is, they react to various sites on cells, and alter cellular function. Certain POPs have also been associated with a number of detrimental health effects, from altered sex ratio to cancer. Some are also known to act as endocrine disruptors, which means they affect hormone activity; this may account for some of the associated health effects.

POPs generally reside or accumulate in high-fat containing tissues. Lactating mothers utilize their fat stores to produce breast milk, and in so doing mobilize the POPs stored in fat as contaminants into the milk. Therefore, human milk is a simple, non-invasive means to monitor POP body burdens.

Although isolated studies conducted on human breast milk and human fat in California indicate that POPs are present, no consistent monitoring is being conducted at this time. Thus a study would need to be designed and initiated to address this issue.

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Mercury Levels in Blood and Other Tissues

Type III

Californians consuming sport fish from lakes and estuaries, containing large amounts of mercury in the sediment, are at risk for having higher body burdens of mercury. Mercury in the environment comes from both natural and man-made sources, and is available in several different forms. These forms interconvert among each other depending upon chemical and physical conditions. Of particular concern is the conversion by aquatic microorganisms of inorganic mercury to methylmercury, a particularly toxic form of mercury. The mercury is transferred from microorganisms to fish, and then to humans consuming these fish. While the brain and the kidneys are the primary targets of mercury toxicity, the developing nervous system in children is especially sensitive to the toxic effects of low-level methylmercury exposure. Thus, exposures to mercury is of great concern for women of childbearing age.

Recent preliminary estimates of blood and hair mercury levels come from the 1999 National Health and Nutrition Examination Survey (NHANES, see www.cdc.gov/nchs/nhanes.htm). NHANES is a continuous survey of the health and nutritional status of the U.S. civilian, non-institutionalized population. A summary of the most recent national data for mercury in blood from NHANES is presented below:

Total blood mercury concentrations (in µg/L) for U.S. children and women

	Sample size	Geometric Mean (95% Confidence Interval)	Selected Percentiles (95% Confidence Interval) 10th	25th	50th	75th	90th
Children-1-5 years	248	0.3 (0.2-0.4)	<LOD*	<LOD	0.2 (0.2-0.3)	0.5 (0.4-0.8)	1.4** (0.7-4.8)
Females-16-49 years	679	1.2 (0.9-1.6)	0.2 (0.1-0.3)	0.5 (0.4-0.7)	1.2 (0.8-1.6)	2.7 (1.8-4.5)	6.2 (4.7-7.9)

Source: National Health and Nutrition Examination Survey, 1999

< LOD means below the limit of detection of the analytical method.
* less than the limit of detection of 0.1µg/L blood.
** Estimate meets minimum standards of reliability, but should be interpreted with caution.
Numbers in parentheses are 95% confidence intervals.

The National Research Council (NRC) completed a toxicologic review of mercury and computed a benchmark dose (BMD) for methylmercury exposure to the fetus associated with an increase in abnormal scores on cognitive function tests in children. The lower 95 percent confidence bound of the BMD was 58 µg/L. The 90th percentiles of mercury levels in children 1 through 5 years old and women of childbearing age are below this level. Approximately 10 percent of women have mercury levels within one-tenth of this level. This study suggests that mercury levels in young children and women of childbearing age are currently below those considered hazardous.

Further monitoring will provide trends regarding the levels of mercury in average Americans. Although national data are and will be available for mercury, California-specific information is not. Mercury is a major concern for those who might consume sport fish derived from California lakes and estuaries. Therefore, in order to address the issue of what are the mercury body burdens for Californians, specific surveillance data need to be obtained.

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Ecosystem Health

Introduction

An ecosystem is an interdependent grouping of living and non-living components in the environment. Ecosystems are defined by the interactions between living organisms, including humans, and their physical environment. All ecosystems are subjected to both natural stressors such as fire, flooding, and wind, and human-induced stressors such as habitat modification and exposure to hazardous wastes and chemicals. On a routine basis, chemical, physical and biological stressors challenge the integrity of ecosystems. Typically, ecosystems can rebound from these stressors. However, if an ecosystem loses a key structural component, the application of another stressor may set off a chain of events that leads to the degradation or potential destruction of the ecosystem. Structural and functional integrity are key factors in the maintenance of viable ecosystems.

In California, the most populous state in the nation, the primary human-related stressors on our ecosystems emanate from modifications of the state's land and water resources. Prime examples include changes in water temperature and flow; habitat quality, quantity and fragmentation; and the release of contaminants from urban and agricultural areas.

Ecosystem Health Indicator

Land cover and management & threatened and endangered species

Land cover
Land cover of major terrestrial ecosystems in California (Type I)

Land management
Land management in California (Type I)

Threatened and endangered species
California threatened and endangered species (Type I)

Health of aquatic and coastal ecosystems

Aquatic life protection and biodiversity
Status of Central Valley chinook salmon populations (Type I)

California least tern populations (Type I)

Persistent organic pollutants in harbor seals (Type III)

Habitat and water quality protection
Clarity of Lake Tahoe (Type I)

Stream bioassessment - invertebrate populations (Type II)

Endocrine-disrupting chemicals in aquatic ecosystems (Type III)

Desert ecosystem health

Alteration in biological communities
Status of the desert tortoise population (Type I)

Habitat degradation
Impacts of off-highway vehicles on the desert (Type II)

Distribution of exotic plants (Type III)

Health of forests, shrub land, and grassland (terrestrial) ecosystems

Habitat quality and quantity

Change in habitat quantity in rangelands and forests (Type I)

Change in forest canopy (Type I)

Pest and disease related mortality in forests (Type I)

Wildfires in forests and grasslands (Type I)

Sustainability of California's forests (Type I)

Loss of biodiversity

Status of northern spotted owl (Type II)

Status of amphibian populations (Type III)

Ozone injury to pine needles (Type III)

Agroecosystem health

Availability of natural resources

Conversion of farmland into urban and other uses (Type I)

Soil salinity (Type II)

Positive and negative environmental impacts

Urban ecosystems

Urban tree canopy (Type III)

Issue 1: Overarching Issues: Land Cover and Management & Threatened and Endangered Species

Underlying any issue related to ecological integrity in California are the issues of the extent and status of ecosystems and threatened and endangered species. The ability to protect important plant and animal habitats and biodiversity begins with knowledge of the geographical distribution of different ecosystems and the way in which these lands are being used.

Sub-issue 1.1: Land cover

Land cover is a general measurement of the abundance of ecosystems. It tracks the total area of both natural ecosystems (forests, grasslands, wetlands, etc.) and transformed ecosystems such as irrigated agriculture, dense urban areas, and development in rural areas. Knowledge of land cover permits an analysis of the change in the extent of the various ecosystems over time, and thus can provide a general measurement of ecosystem health and viability. Land cover measurements help define the broadest categories of natural versus altered ecosystems.

Indicator

Land cover of major terrestrial ecosystems in California (Type I)

Sub-issue 1.2: Land management

How land is managed within the broad land cover types also influences ecological health. The greatest ecological impacts caused by humans result from land management decisions. As land managers and landowners change their management objectives, lands that formerly had minimum human impact can be subjected to ecosystem-disturbing activities. These activities include replacing natural biological communities with agricultural systems, introducing hydrologic or chemical cycle alterations, and changing the earth's surface by creating urban areas. The two key characteristics of land management are ownership (public vs. private) and use ('reserved' for ecological integrity or 'working' for the production of commodities or a combination of the two).

Indicator

Land management in California (Type I)

Sub-issue 1.3: Threatened and endangered species

California has one of the most diverse assemblages of plants, animals, and natural communities in the United States. Human activities have threatened the viability of many populations of plants and animals, causing some to become threatened, endangered, or extinct. Both federal and state laws have been enacted to protect species at risk of extinction. Not only is the protection of these species important for the preservation of biodiversity, but the threatened status of a species indicates a decline in the status of the ecosystem as a whole.

Indicator

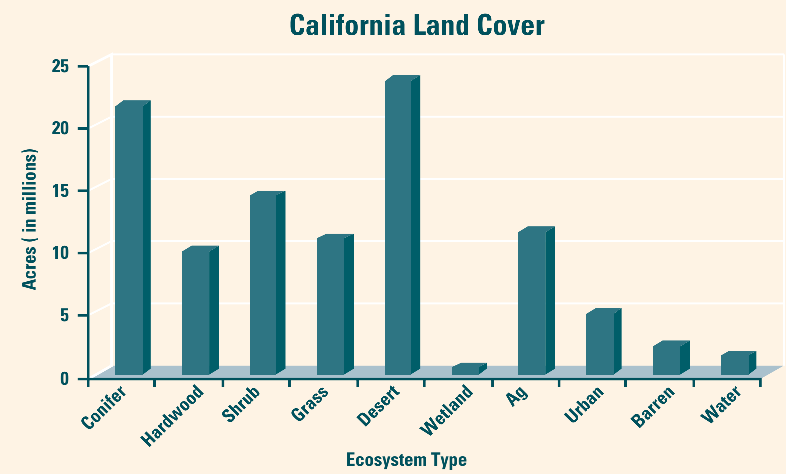
California threatened and endangered species (Type I)

Type I

Level 4
Goal 6

Land Cover Of Major Terrestrial Ecosystems In California

The extent of land cover in California as of 1997.



What is this indicator showing?

The indicator shows the current distribution and extent of natural and human-altered ecosystems in the state. Forests are subdivided into conifer and hardwood. Barren lands, those without any vegetation, are primarily those above the tree line. Water includes lakes, reservoirs, rivers, and streams. The graph below shows the total acreage in each broad category.

Why is this indicator important?

Land cover is a general measurement of the abundance of a particular ecosystem. Land cover measurements help classify the broadest categories of natural versus altered ecosystems. As the total acreages of land cover change over time, inferences can be made about changes to specific ecosystems or habitats that might be placed "at risk." Maps of changes in land cover can alert policy makers and planners to patterns in changes in land cover that are useful in decision making. The geographical presentation of the information is particularly useful for policy makers in minimizing fragmentation of wildlife habitat, a major threat to ecological health.

This indicator is essential to monitoring the extent and general condition of California's ecosystems. As information from the California Land Mapping and Monitoring Program evolves, repeatable information, spatially displayed for tracking changes in terrestrial ecosystems, will be available.

Land Cover of California

See full color map on page 255

What factors influence this indicator?

California contains approximately 100 million acres of land. The largest category is forested lands, which cover about 31 million acres. The desert is the next largest category, covering about 24 million acres, followed by shrub land, with 14 million acres, and grassland with about 11 million acres. Wetlands and water cover 2 million acres.

While this indicator portrays the broad categories of ecosystems, the underlying classification system that was aggregated to develop it provides very detailed descriptions of habitat extent and condition. These additional details are available on different layers of the Geographic Information System (GIS) maps developed and maintained by the Fire and Resource Assessment Program (FRAP) at the Department of Forestry and Fire Protection (CDF).

Technical Considerations:

Data Characteristics

No single vegetation mapping effort provides GIS data adequate to address broad resource issues throughout the state. In order to provide the most solid basis for statewide analyses, FRAP staff has used several digital map sources and merged them into a single GIS data layer.

A major component of the land cover data comes from the California Land Cover Mapping and Monitoring Program (CDF and U.S. Forest Service cooperative), which develops products for forest and range areas of California that cover approximately 65 percent of the state.

This program provides consistent, high quality data to manage, assess and protect California's diverse vegetative resources. Landsat Thematic Mapper (TM) satellite imagery is used to map vegetation over repeated five-year cycles. California Land Cover Mapping and Monitoring Program land cover products are developed to meet federal Geographic Data Committee standards and the needs of various state and local cooperators. Land cover map products include cover type, tree size and canopy closure attributes with a minimum map unit of 2.5 acres.

Many other data sources are used to create the land cover map. Some of the other sources include U. S. Geological Service (USGS) hydrography for water; U.S. Bureau of Census for urban areas; Department of Fish and Game wetlands data; and Department of Conservation Farmland Mapping Program for agricultural lands.

Strengths and Limitations of the Data

Combining disparate GIS layers is problematic due to differences in scale, accuracy, age, specificity and purpose of each individual data set. Merging data from multiple sources required addressing these differences in scale, resolution and consistency. In addition, each data set had to be cross-walked into a common classification system called the California Wildlife Habitat Relationships system (CWHR).

Spatial registration of these products to base maps between 1:60,000 and 1:100,000 scale limit the utility of the data for some applications. Users familiar with USGS 1:24,000 scale topographic maps and Digital Ortho Photo Quarter Quads (DOQQ) find these data coarse for planning projects "on the ground." Registration of obvious features such as lakes can vary and often have "blocky" rather than smooth edges. Features smaller than 2.5 acres are subsumed by surrounding vegetation types and small linear features such as roads and riparian corridors are not captured well.

References:

Fire and Resources Assessment Program (FRAP), California Department of Forestry, frap.cdf.ca.gov

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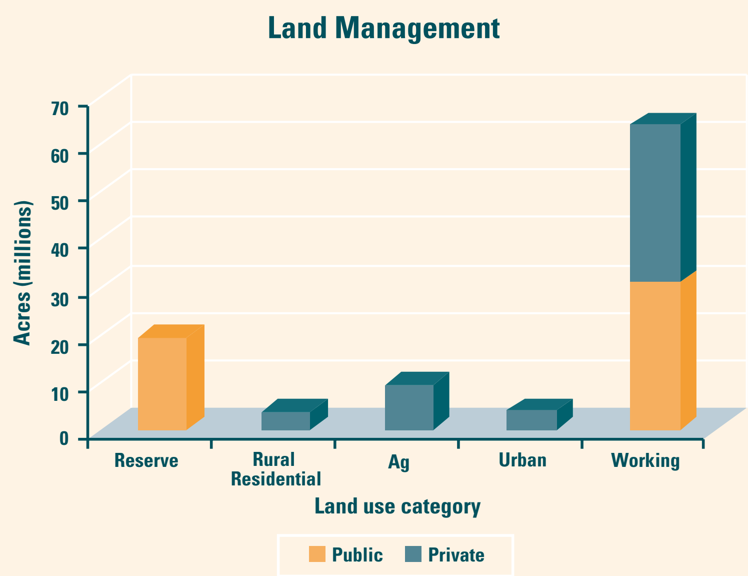
Type I

Level 4
Goal 6

Land Management In California

The ownership and management of land are shown by this indicator.



What is the indicator showing?

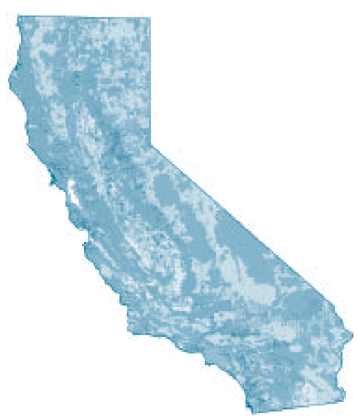
Nineteen percent of California lands are managed to maintain a high degree of ecological integrity (the Reserve category). Sixty-four percent of lands fall into the "working" category, which provides varying degrees of habitat value. The remaining lands are significantly transformed by human activities.

Why is this indicator important?

Identifying the major types of land management and uses is fundamental to understanding the impact that policy decisions have on current ecosystems. The **land cover** indicator defines natural vegetative types of land (e.g., desert, forest, grassland, aquatic, as well as agricultural and urban covers). This indicator, **land management**, defines the owner's primary objective for these lands, a key factor in determining the compatibility and flexibility for maintaining ecological integrity. For example, forests are typically managed as a working landscape for the production of timber when in private ownership, but can also be a reserve landscape when held by the state or federal government as a park. Changes in land management and use can have significant impacts on the integrity of the ecosystem. These changes include replacing natural biological communities with agricultural systems, altering chemical or hydrological cycles such as those caused by building dams, and changing the earth's surface by creating concrete-covered urban areas. Classifying land management is a fundamental step in understanding areas of undisturbed versus altered ecosystems, defining the components of ecosystems most at risk, and establishing a system for monitoring land use change.

The graph above shows that 19 percent of California lands fall into the Reserve category, indicating that they are managed to maintain a high degree of ecological integrity. About 64 percent of California lands are in the Working category, and these lands provide habitat of varying quality. The remaining lands are significantly transformed by human activities.

Land Management of California



See full color map on page 256

What factors influence the indicator?

This indicator reflects the present status of the combination of land management, ownership and major uses of land in the state. This indicator reflects the potential ecological impacts of land use decisions. Maintenance of overall ecological health is closely related to the use of the land. As land use decisions change, increases or decreases in ecological integrity result. In future years, trends will develop as additional data are collected. The map reflects acres of land in the following two classification schemes:

1. Ownership:
   - Public: those lands whose management goals are set through public procedure and by public agencies.
   - Private: those lands whose use is determined by the owner.
2. Land Management and Compatibility with Ecological Integrity:
   - Reserve: lands permanently managed for the maintenance of ecological integrity. Example: State parks, wildlife areas.
   - Working: lands managed for some degree of commodity output, but also for the maintenance of some degree of natural ecosystem integrity. Example: private timber production forests and ranches.
   - Agriculture: irrigated lands managed for the production of food or fiber with modest consideration given to ecological attributes in certain cases. Example: cotton, rice fields, or vineyards.
   - Rural Residential: lands where housing densities are more than one house per 20 acres but less than one house per acre. These lands are usually found within working or agriculture categories and reduce natural vegetation and habitat quality due to the presence of settlement.
   - Urban: lands having housing densities of one unit per acre or greater or commercial lands with very little ecological value.

The above categories are useful for understanding the key management goals of the land. However, within any category there are exceptions. For example, healthy creeks exist within some dense urban areas and dense developed areas exist within many parks and reserves.

Nearly 64 percent of the state's land is in the **working landscape** category. These lands are natural, managed ecosystems, such as forests, woodlands, and grasslands involving some level of commodity production or active recreational use but with a relatively high level ecological integrity. Nineteen percent of the land is publicly owned and reserved to promote ecological integrity. The rest of the landscape is fundamentally transformed by high-density urbanization (four percent), rural residential areas (four percent), or irrigated agriculture (ten percent). Reserve lands (19 percent) are far less prominent than lands that are highly managed (Working/Ag/Urban) and are unequally spread across the state. This distribution leads to protection of different ecosystems to different degrees and complicates management for ecological integrity.

Working landscapes such as forests and grasslands will potentially play a very important role in the future development of the state. First, they are important sources of natural areas and open spaces. They provide habitat for many species of animals and provide recreational opportunities for hundreds of thousands of people. On the other hand, it is likely that a significant portion of new urbanization will occur on these lands. Explicit land use planning is needed to maintain their ecological values.

Urban and various urban mixtures (rural, suburban, etc.) categories represent nearly eight percent of the state's land uses. These are the sites of the greatest population growth and present challenges to maintain some degree of ecological integrity.

Technical Considerations:

Strengths and Limitations of the Data

The data presented in this version are not highly maintained or updated. A new version, with updated mapping layers, is scheduled for release in 2002. Trend analysis between these versions is difficult due to changes in mapping techniques to improve "accuracy" of the information. Since the methods used to prepare this map are different than those that will be used in future versions, comparability will only be approximate.

References:

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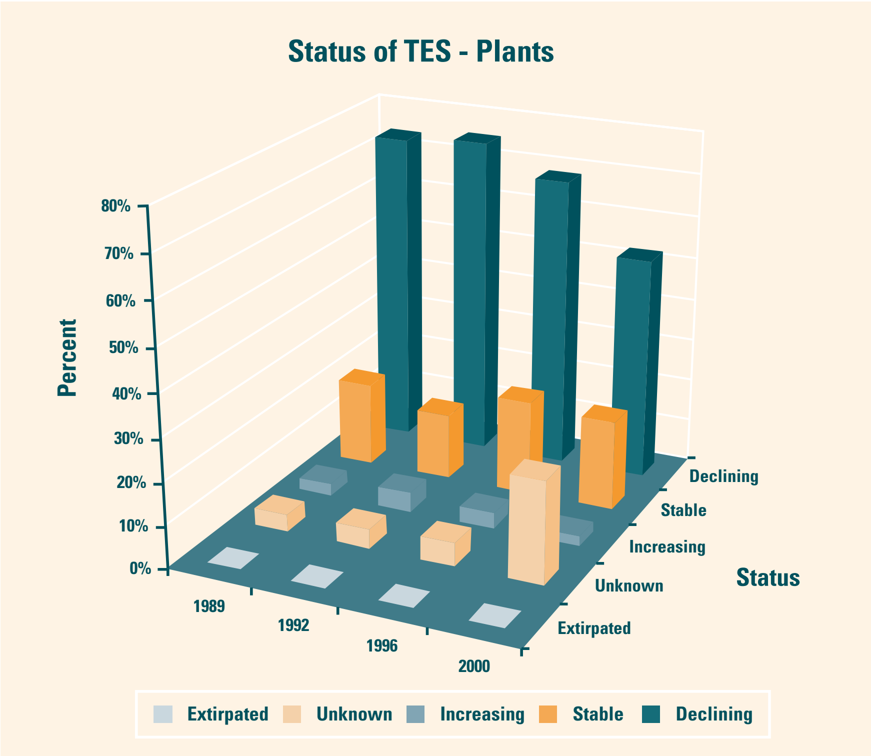
California Threatened and Endangered Species

Estimates of changes in the populations of plants and animals on the threatened and endangered species (TES) list.

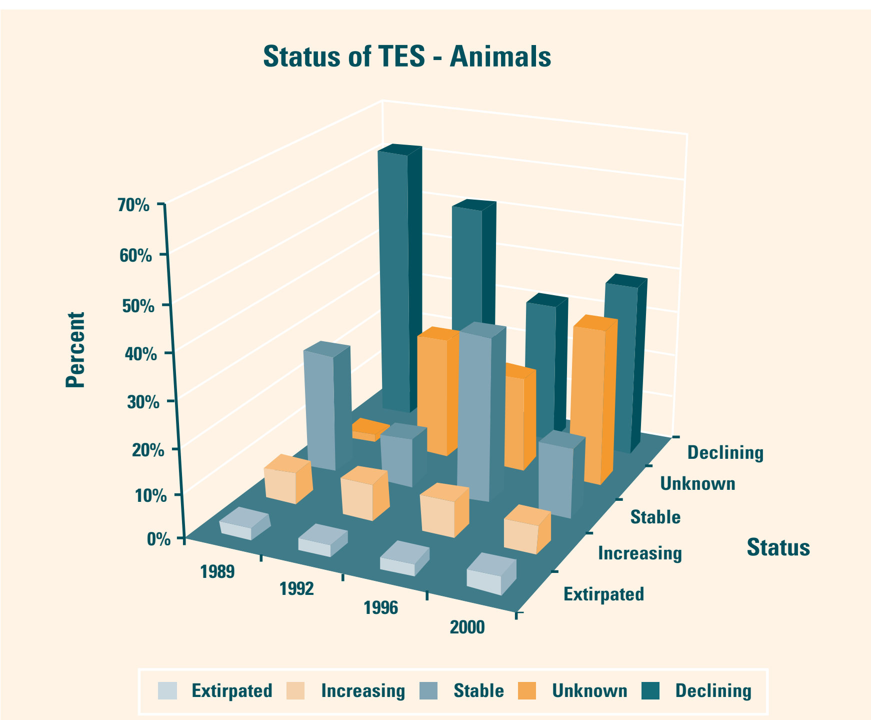
Type I

Level 6
Goal 6



What is the indicator showing?

Over the past 12 years, plants on the California threatened and endangered species list with populations that are "declining" make up the largest category, while those whose populations are "increasing" represent the smallest category. Essentially no plants have been extirpated (species no longer found in California). The number of plants in the "unknown" category is increasing.



Between 1989-2000, trends for TES animals show that the percent of animals in the "unknown" category has increased. The population of about 5 percent of TES animals is "increasing". Since 1989, there appears to be a reduction in the number of animals in the "declining" category.

Why is the indicator important?

The status of threatened and endangered species (TES) is a useful indicator of biodiversity. Collectively, TES occur in a wide variety of habitats throughout the state. Changes in their abundance and distribution may indicate more substantial problems with many other species and habitats. These plants and animals are among the most sensitive to human impacts on our environment, such as habitat loss and degradation. They are listed as threatened or endangered because they "are in danger of or threatened with extinction because their habitats are threatened with destruction; adverse modification or severe curtailment, or because of overexploitation, disease, predation or other factors." These species are also among the most studied in the state. The California Department of Fish and Game regularly issues statewide status and trend information, based on professional judgment, on the status of species on the TES list.

What factors influence this indicator?

The fact that the "unknown status" category accounts for about 20 percent of TES plants and 35 percent of TES animals reflects substantial uncertainty. There is considerable need for more scientific data on the populations of many California threatened and endangered species to learn about their true status and condition. Insufficient resources do not allow for full assessment of population status of all listed plants and animals. Of additional concern is the fact that, with the exclusion of those TES that are extirpated, the "increasing" category for both animals and plants is the smallest category.

This indicator is influenced both by the nature of the data collection process and by factors that affect the long-term viability of individual species. These data represent the best professional judgment of biologists, but there is variability in both the assessment and reporting methods. Species viability in California is most strongly influenced by loss of habitat. This loss is due most often to urban expansion (National Wildlife Federation, 2001), but it also occurs when natural lands are converted for commercial uses or when water is diverted from natural channels. Habitat degradation is a secondary, though still very important factor. This loss in habitat quality may occur due to invasive species, increased human access during sensitive periods, creation of dispersal barriers, habitat fragmentation, and isolation of populations. For some species, other factors such as diseases, poisoning, roadkills, and pollution, are also important influences on population trends.

Technical Considerations:

Data Characteristics

The information in the graphs has been simplified for the sake of readability. The “stable to increasing” and “increasing” categories have been pooled to indicate the groups that are increasing; the “stable to declining” and “declining” categories have been pooled to indicate the groups that are in decline. Invertebrates were excluded as a species group due to the very limited number of species listed.

Strengths and Limitations of the Data

This indicator describes only those species that are listed under the California Endangered Species Act. Although this list overlaps somewhat with those species listed under the federal Endangered Species Act, it does not include approximately 112 federally listed species. It also does not include some 1,400 other species that are considered biologically rare or sensitive in the state. The California Department of Fish and Game issues regular reports on the status and trends of state-listed species, although due to funding limitations these reports rely heavily on professional judgments. These judgments will vary from year to year and from species to species, depending on current staff expertise, and degree of coordination with other agencies and organizations that are familiar with individual species.

References:

California Department of Fish and Game. 2001. *The Status of Rare, Threatened, and Endangered Animals and Plants of California Annual Report of 2000*. State of California, Resources Agency.

National Wildlife Federation. 2001. *Paving Paradise: Sprawl’s Impact on Wildlife and Wild Places in California*. Posted at: www.nwf.org/smartgrowth/pavingparadise.html.

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Indicators

Status of Central Valley Chinook Salmon Populations (Type I)

California Least Tern Populations (Type I)

Stream Bioassessment – Invertebrate Populations (Type II)

Persistent Organic Pollutants in Harbor Seals (Type III)

Endocrine-Disrupting Chemicals in Aquatic Ecosystems (Type III)

Issue 2: Health of Aquatic and Coastal Ecosystems

Sub-issue 2.1: Aquatic life protection and biodiversity

The animals and plants that live in coastal/marine and freshwater/inland waters are valued resources and their diversity and abundance are key factors that reflect the health of these environments. These natural resources are threatened by loss of habitat and competition with introduced species, as well as degradation in water quality and depletion of natural resources beyond the system's capacity to recover.

Indicators selected to represent this issue are identified in the box below. Chinook salmon and least tern were selected as sentinel species for instream and coastal fish and birds since reliable data are available. To assess of the quality of the aquatic habitat, the Stream Bioassessment, a measure of the abundance and diversity of stream invertebrates, was chosen as an indicator. Since invertebrates such as fly larvae are near the base of the aquatic food chain, the status of these organisms will impact many other aquatic species. Additionally, they are among the most sensitive to contaminants. Two additional issues of importance to the biodiversity of the aquatic ecosystems are the bioaccumulation of persistent organic pollutants (i.e., dioxins and polychlorinated biphenyls) and the presence of endocrine disrupting chemicals. Both can interfere with reproduction and thus have significant effects on populations of aquatic organisms.

Indicator

Clarity of Lake Tahoe (Type I)

Sub-issue 2.2: Habitat and water quality protection

The maintenance of aquatic resources is dependent upon preservation of physical habitat as well as suitable water quality and quantity. California has over 10,000 lakes, reservoirs, and ponds and over 64,000 miles of perennial rivers and streams. Its coast is nearly 1000 miles long. California contains valuable wetlands, both along the coast and inland, the majority of which have been lost or substantially changed. Changes in physical parameters such as substrate type, temperature, salinity, and dissolved oxygen can have substantial effects on the biological resources in aquatic ecosystems as well. Excess nutrients, such as nitrogen and phosphorus, can lead to eutrophication, a condition in which algae depletes light and oxygen in the system. Contaminants such as heavy metals and polycyclic aromatic compounds can collect in the sediment, presenting a risk to many aquatic organisms. Key abiotic resources, such as water quality and quantity, are essential to maintaining the health of aquatic ecosystems. Urbanization and infrastructure development, industry, commercial shipping and fishing, and recreational activities are additional factors that have the potential to negatively impact aquatic habitats.

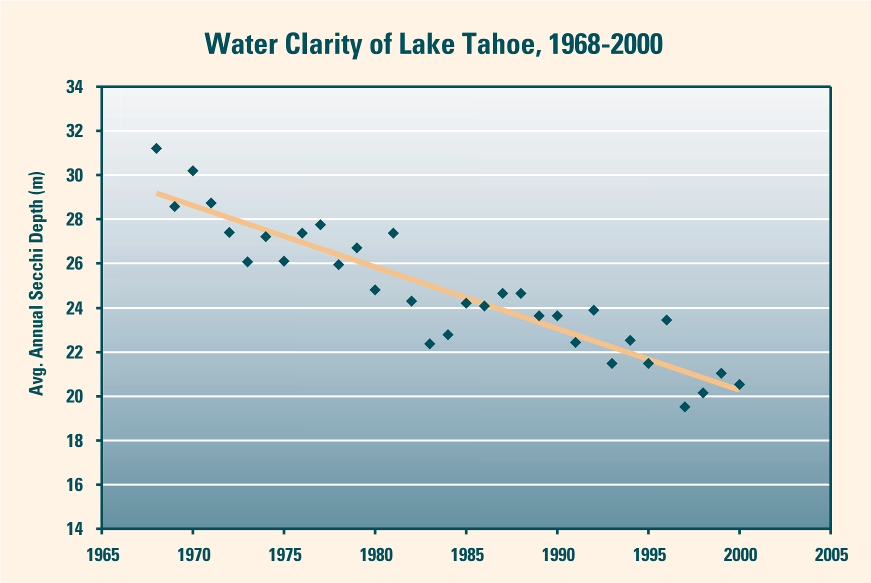
The indicator to represent the status of aquatic habitat is the Clarity of Lake Tahoe, a measure of the extent of nutrient and sediment pollution, leading to eutrophication. Eutrophication of lakes is often a consequence of human activity in or around aquatic habitats. In future years, additional lake monitoring data from throughout the state, as well as other indicators of aquatic habitat, will be added to the report.

Clarity of Lake Tahoe

Transparency of lake water is an indicator of ecological health.

Type I

Level 6
Goal 2, 4, 6



What is the indicator showing?

The clarity of Lake Tahoe's water has decreased since 1968. These changes are associated with eutrophication, a process where nutrient levels rise and cause plant and algae growth to increase. In addition, suspended sediments have contributed significantly to decreased clarity.

Why is this indicator important?

Lake Tahoe, a pristine, crystal-clear high altitude lake, is considered one of the 'jewels' of the Sierra. As such, Californians place a high value on the ecological condition of this lake. While this indicator only reflects the ecological condition of the Lake Tahoe watershed area, this type of assessment can be used to determine the condition of other developed watershed areas containing lakes. The graph above shows decreases in lake water clarity measured by the depth that a round disk can be seen when lowered into the lake. It is indicative of eutrophication, a natural aging process in lakes that involves increased amounts of nutrients and algae in the water, with one of the most noticeable results being reduced water clarity. Human activities, especially those that cause increases in the concentration of nutrients such as phosphorus, can cause higher than normal rates of eutrophication, as observed in Lake Tahoe. Increases in lake algae can change the appearance and even odor of a lake, and can cause periodic decreases in water oxygen levels. Oxygen depletion can harm many organisms and fundamentally change the ecology or the types of life that can survive in the water body. For example, the suitability of the lake to support cold water fish such as trout, sucker, and Kokanee salmon may decrease in advanced stages of eutrophication. More information about changes at Lake Tahoe can be found on the website of the University of California at Davis Tahoe Research Group (see references).

What factors influence this indicator?

Data collected at Lake Tahoe since the late 1960s indicate that water clarity has decreased. Water in the lake has been losing transparency at an average of about one foot per year, a decrease of 34 percent since 1968. During this same period, biological changes such as increases in algae growth along the edges of the lake have been observed. These changes have been associated with inputs of nutrients from the atmosphere and the watershed as well as from suspended clay and silt particles brought in through streams (Tahoe Research Group, 2000). Watershed land-use practices and atmospheric inputs are primary factors that influence the clarity and trophic state of Lake Tahoe. Typical causes of accelerated eutrophication in lakes include changes in watershed practices that allow for increased erosion and nutrient release and the input of nutrient-rich urban or agricultural runoff water.

Technical Considerations:

Data Characteristics

This indicator represents eutrophication-related problems in lakes. It is an integrative indicator since the algal component of clarity loss infers changes in biologically meaningful characteristics such as algae biomass, invertebrate and fish assemblages, nutrient levels, and oxygen concentration profiles. A long-term data set on water clarity readings at Lake Tahoe has been carefully maintained and made available by UC Davis researchers (Tahoe Research Group, 2001; Horne and Goldman, 1994). In addition to being simple and relatively easy to understand, this type of indicator is being used in other states around the country through a national volunteer-based water clarity monitoring effort, offering the opportunity to compare our findings with those of other states (The Great North American Secchi Dip-In Website, 2001).

Clarity measurements were made using a Secchi disk that was lowered into the lake water. A Secchi disk is a flat, 8 or 10 inch black and white disk that, when lowered into the water, provides a measure of optical clarity measured at the depth where the disk can no longer be seen. Annual averages of these measurements were used for Lake Tahoe since clarity readings on this lake are measured every 12 days.

Strengths and Limitations of the Data

Clarity measurements with Secchi disks are simple and relatively robust indicators of lake health. Because of Lake Tahoe's large size and relatively small watershed, as well as its high altitude, pristine condition, and urbanized setting, it is fairly unique among California lakes. Lake Tahoe is monitored frequently; however, there are many lakes in the state for which no such readings are taken. Some regions and programs monitor extensively, such as the Department of Water Resources' Northern District, while others monitor very little. Fragmented data sets, with gaps in both spatial and temporal coverage of California lakes, have been obtained for less than one percent of California lakes, reservoirs, and ponds. To assess the health of California lakes, monitoring efforts may be warranted for other lakes, such as Lake Elsinore, Salton Sea, Mono Lake, and Clear Lake, on a regular basis. The Secchi disk readings may not always be the most appropriate indicator of lake health for all lakes, and in such cases more appropriate measurements should be made so that responsible agencies and the public have information about the health of a key natural resource.

References:

Horne, A.J., C.R. Goldman. 1994. *Limnology*. McGraw-Hill, Inc., New York. pp.507-508

The Great Secchi Disk Dip-In Website, dipin.kent.edu/

U.C. Davis-Tahoe Research Group. 2000. *Annual Progress Report 2000, Water Quality, Air Quality & Forest Health*. trg.ucdavis.edu.

U.C. Davis-Tahoe Research Group. 2001. Lake Tahoe Index Station Data Supplied by U.C. Davis-Tahoe Research Group.

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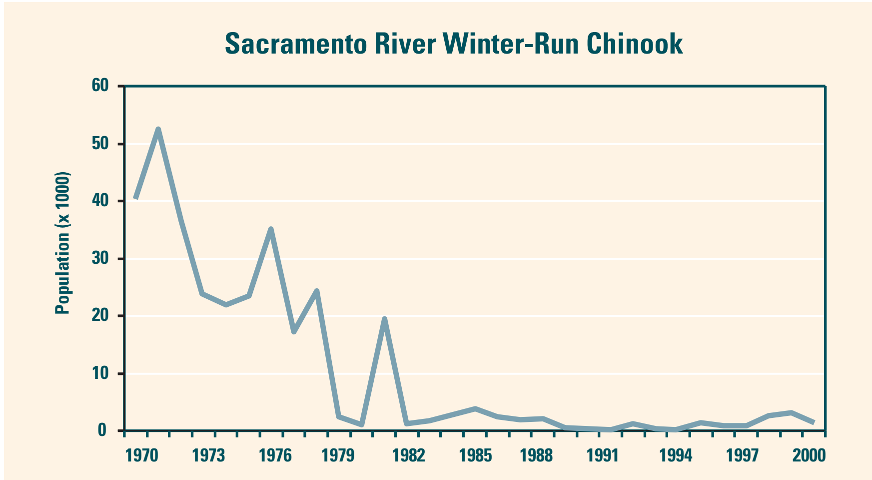
Type I

Level 6
Goal 6

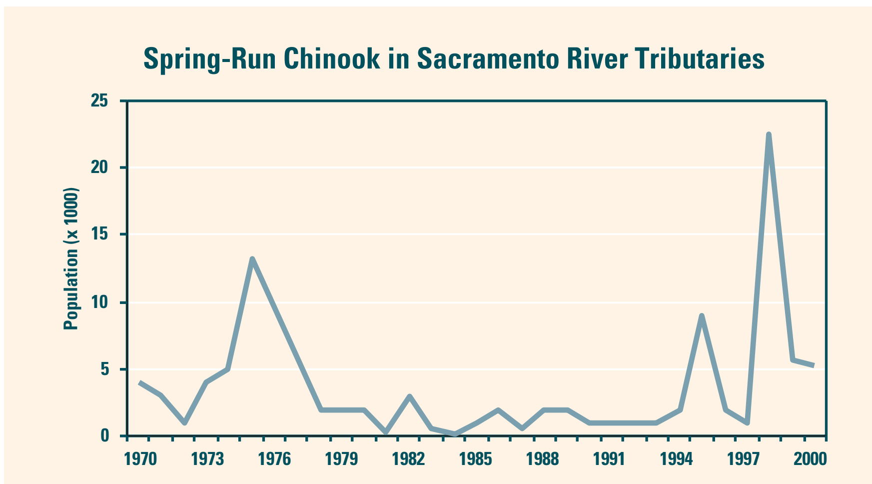
Status of Central Valley Chinook Salmon Populations

The status of Central Valley chinook salmon populations is a general indicator of the health of river systems in the Central Valley.

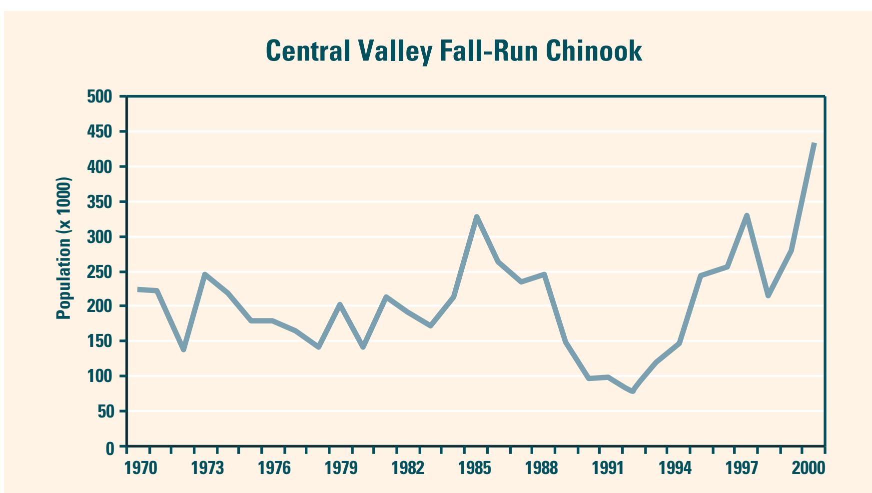


What is the indicator showing?

The endangered winter-run chinook salmon population has shown a significant decline over the past 30 years. In recent years, population levels have increased, but remain well below levels defined for recovery.



Spring-run salmon populations in Mill, Deer, and Butte Creeks, tributaries of the Sacramento River in the northern Sacramento Valley, have shown some recovery in recent years. These three creeks support the only remaining significant non-hybridized populations of the threatened Central Valley spring-run chinook.



Spawning returns of fall-run chinook salmon in the Central Valley have fluctuated over the past 30 years, showing some increase in recent years. Fall-run chinook salmon returns are significantly influenced by hatchery production and ocean harvest regulations.

Why is this indicator important?

Four chinook salmon runs are recognized in the Central Valley, differentiated by the timing of the adult spawning migration (fall, late fall, winter, and spring-run chinook salmon). Chinook salmon have been historically valued and have become part of the cultural and natural heritage of northern California. Commercial and recreational fishing for salmon has contributed significantly to the economy. The estimated California economic impact for 2000 was approximately $40 million dollars. Historically, this contribution has been much greater (PFMC, 2000).

Many of the salmon runs in the Central Valley are on the federal or state endangered species list: Sacramento River winter-run chinook salmon is state and federally-listed as endangered, Central Valley spring-run chinook salmon is state and federally-listed as threatened, and Central Valley fall and late fall-run chinook salmon are federally designated as a candidate species. Historically, these runs were abundant in the waters of the Sacramento and San Joaquin Rivers. Narratives from the late 1880s describe these rivers as “teeming with salmon” (Yoshiyama et al., 1998). Based on data from early commercial catch records, scientists at University of California, Davis conservatively estimate that chinook salmon stocks reached between one to two million spawners annually. Today, the winter and spring runs are a fraction of their historic levels (Yoshiyama et al., 2000). Significant regional efforts, including the CALFED Bay-Delta Program and Central Valley Project Improvement Act (CVPIA), have devoted considerable resources to the recovery of these runs.

What factors influence this indicator?

Because the winter and spring runs typically spawn farther upstream than the fall-run salmon, their populations have been most significantly impacted by dam building in the state. Blockage of access to spawning and rearing areas due to dam construction has had the greatest impact on these runs, significantly reducing the availability of habitat from historic levels. Other factors contributing to the decline include ocean harvest, changes in the frequency, amount and timing of instream flows, water temperature changes, delay of passage at artificial barriers, contaminant discharges, loss of riparian habitat, loss of spawning gravel, and accidental trapping of young fish in water diversions. In many cases, these stressors pre-date 1970, but their effects continue to the present.

In contrast to the winter run, the population of spring-run chinook salmon in Mill, Deer, and Butte Creeks have fluctuated in the past 30 years, showing some recovery in recent years. This recovery has been associated with a number of factors, including the removal of diversion dams, instream habitat and flow improvements, and improved watershed management.

In general, fall-run chinook populations in the Central Valley have been more stable over the past 30 years. Fall-run salmon have fared better in part because they spawn primarily in the lower reaches of the rivers, those below 1000 feet elevation, in reaches that have not been obstructed by dams. The life history of fall-run chinook is more compatible, in general, with current water management practices in the Central Valley as well. However, the number of fish that return to freshwater to spawn naturally, also referred to as escapements, in the Sacramento River basin are influenced by hatchery production (PFMC, 2001); hence the size of the Sacramento basin runs may be a poor indicator of ecological health. The abundance of natural fall-run chinook in the San Joaquin River basin, less influenced by hatchery production, continues to be low following several above-average water years.

Significant concern exists regarding the genetic effects of hatchery rearing on wild salmon populations. Some studies suggest that hatchery-raised fish are less successful than wild fish in reproducing under natural conditions (Levin and Schiewe, 2001). Long-term hatchery production may adversely affect the fitness of wild populations in a variety of ways. The National Academy of Sciences recently released an analysis of the genetics of Atlantic Salmon, another salmonid in a related genus, and found distinct differences between hatchery and wild fish, those spawning naturally for at least two generations (National Academy of Sciences, 2002). This report may provide some insight into genetic differences between hatchery and wild chinook salmon.

Due to concerns over habitat degradation, threats to genetic integrity due to hatchery production, and relatively high ocean and inland harvest rates, Central Valley fall-run chinook have been designated, along with the late fall-run, as a candidate species under the federal Endangered Species Act.

Technical Considerations:

Data Characteristics

Spawning populations of chinook salmon are estimated each year by carcass surveys, direct counts at dams, redd (spawning nest) counts, and snorkel surveys. Carcass survey estimates are based on a mark-recapture method. Population sizes are statistically estimated from the sequential sampling of tagged salmon carcasses.

Strengths and Limitations of the Data

The population estimation process is subject to error and provides reasonable estimates rather than exact numbers. Estimates of natural spawners include both hatchery-reared fish and fish spawned in the wild. At present, the contribution of hatchery-reared fish to the natural spawning escapement is not known with any degree of accuracy.

In addition, spawning escapement surveys cannot assess the effects of different stressors on the populations. The number of fish that return to freshwater to spawn is affected by numerous environmental factors and by rates of harvest in both ocean and inland areas.

There is a need for improved monitoring of chinook salmon populations in the Central Valley, including the ability to differentiate between hatchery and wild fish. Fishery management agencies such as National Marine Fisheries Service, California Department of Fish and Game, and U.S. Fish and Wildlife Service are working toward improved monitoring programs, in part through funding provided by programs pursuant to the Central Valley Project Improvement Act (CVPIA) and the CALFED Bay-Delta Program.

References

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CALFED Bay-Delta Program, www.calfed.ca.gov.

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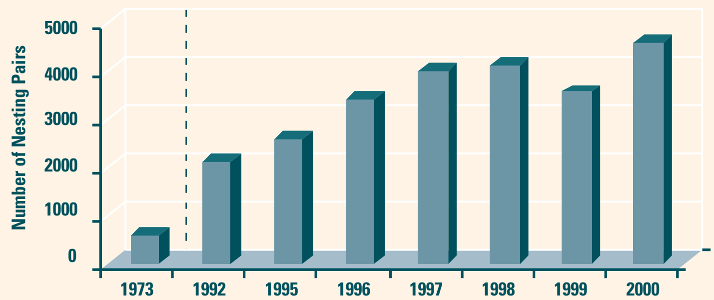
Type I

Level 6
Goal 6

California Least Tern Populations

Populations of this bird, which is on the federal and state lists of endangered species, have partially recovered.



What is the indicator showing?

The least tern population has improved since 1970, but in the late 1990s, the rate of increase in the population slowed. Since much of its nesting habitat is disturbed by humans, these birds need to be monitored closely in the future.

Why is this indicator important?

The California least tern, a seabird on both the federal and state endangered species list, nests in colonies on sandy beaches and other flat, open areas along the coast. Nesting habitat along the coast has been degraded by habitat modification and human disturbance. Rising least tern populations signify the success of intensive management efforts, including monitoring of nesting colonies, protecting nesting sites by reducing human access, managing vegetation, and controlling predators.

What factors influence this indicator?

The population of least tern has been increasing, with a reproductive success rate of 0.7 fledglings per adult pair. The number of active breeding sites remains steady at between 34 to 39 sites during the 1990s. Most of the population increase is accounted for by the robust growth in 9 or 10 large colonies, while most other sites have populations that are either decreasing, not significantly increasing, or generally do not have good breeding success.

In the early 1970s, when California least terns were listed as endangered by the federal government and California, their population in California was estimated at 600 breeding pairs. Active management of the tern began in the 1970s and intensified in the 1980s. By 2000, the population had increased to about 4600 pairs, nearly an eightfold increase.

California least terns are migratory birds that winter in Latin America and nest along the Pacific coast from southern Baja California to San Francisco Bay. They nest in colonies on bare or sparsely vegetated flat areas on the coast. Nesting sites are now on isolated or specially protected sand beaches or on natural or artificial open areas in remnant coastal wetlands, in places where small fish are abundant. Development and recreational use of California's coast have largely eliminated the natural nesting habitats of the terns (DFG, 2000). Human activities and predators associated with humans (e.g., domestic cats, non-native red foxes, crows, and ravens) continue to place nesting colonies at risk.

Interestingly, the Alameda Naval Air Station is one of the largest and most successful breeding colonies in the state, and the only substantial colony in northern California. The terns have nested on the runways of the Naval Air Station for years, and the Navy managed the colony. As part of the federal government's disposal of the Naval Air Station, a 500-acre parcel including the runways was transferred to the U.S. Fish and Wildlife Service to be included in the San Francisco Bay National Wildlife Refuge. Larger breeding populations regularly nest at Camp Pendleton, Mission Bay, Huntington State Beach, and Venice Beach.

Technical Considerations:

Data Characteristics

California least terns compete with humans for one of the most valuable and scarce resources in the state — undeveloped coastal lands. The fact that the terns survive on remnant nesting sites amidst a highly developed landscape demonstrates that intensive wildlife management efforts can succeed.

Strengths and Limitations of the Data

Annual surveys of tern colonies are conducted by cooperating agencies including military facilities, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game, with valuable help from private groups and other volunteers. However, ongoing surveys are dependent on adequate funding.

Reference:

DFG, 2000. *The Status of Rare, Threatened, and Endangered Animals and Plants of California, Annual Report.* California Department of Fish and Game.

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Type II

Stream Bioassessment – Invertebrate Populations

Why is this indicator important?

Biological assessments or bioassessments are evaluations of the condition of water bodies using surveys and other direct measurements of resident biological organisms, i.e., invertebrates, fish, and plants. The health of aquatic ecosystems has traditionally been assessed with indirect measures emphasizing chemical tests. Bioassessment, on the other hand, is a direct measure of the condition of aquatic organisms so that any potential adverse effects of multiple aspects of poor water quality or inadequate habitat can be evaluated. U.S. EPA has been working with California to develop a cost-effective and reliable measure of the physical and biological integrity of the state's water bodies. The goal of this project, known as the Western Pilot Environmental Monitoring and Assessment Program (E-MAP), is to conduct physical and biological assessments and develop Indicators of Biological Integrity (IBI) for a variety of aquatic organisms. The Department of Fish and Game has recently completed Year one of a four-year monitoring effort to conduct bioassessment in streams of California. Because streams were randomly selected throughout the state, the results of this bioassessment effort should accurately reflect the condition of streams throughout California. U.S. EPA's intent is to have a first set of data points out for review by the year 2004 and then to turn the project over to the state for modification and long-term implementation.

Invertebrates living in the sediment of streams, also known as benthic macroinvertebrates, are the focus of California's effort. They are being collected, counted, and classified according to species. Several biological metrics are used to calculate the "health" of the macroinvertebrate population, including taxa richness, community composition, tolerance measures, and feeding guilds. These values are then used to calculate the benthic macroinvertebrate IBI. High IBI values indicate a healthy population of macroinvertebrates.

What factors influence this indicator?

The IBI will tell us a great deal about the overall health of aquatic ecosystems. When human activities have detrimental effects on streams, the IBI value declines. Bioassessment measures key components of the aquatic ecosystem - biological community diversity, productivity, and stability. The degradation of the physical habitat, which can include alteration of substrate type, tree cover, and appropriate stream or river bottom, is a key factor that is important to the health of aquatic organisms. Poor water quality associated with factors such as high levels of suspended particles, changes in water temperature or water quantity, pesticide runoff, or effluent from industrial activities, can also adversely affect aquatic ecosystems. In many cases, mortality or impairment of reproduction occurs at contaminant levels much lower than those that affect fish. Since macroinvertebrates serve as food for fish, and in turn, fish serve as food for birds and mammals, the status of these organisms is important for maintenance of the health of the entire aquatic ecosystem.

Reference:
California Department of Fish and Game, Aquatic Bioassessment Workgroup website:
www.dfg.ca.gov/cabw/cabwhome.html

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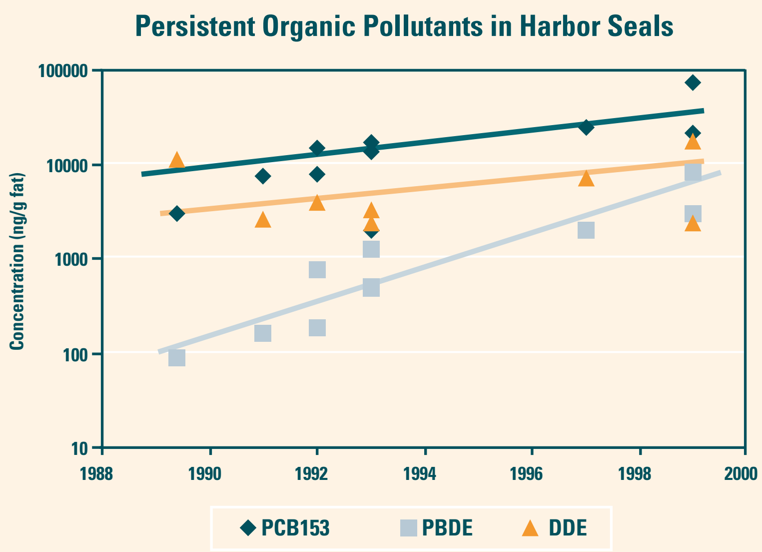
Persistent Organic Pollutants in Harbor Seals

Type III



What is the indicator showing?

This pilot study shows that certain POPs are accumulating in harbor seal blubber. There was an exponential increase in PBDEs, a small increase in PCBs and no change in organochlorine pesticides (DDE shown) over the last decade. Data for this graph came from analysis of fat tissue of nine harbor seals killed in boating or other accidents.

Why is this information important?

Persistent organic pollutants (POPs) are fat loving or lipophilic contaminants that include polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs) (reviewed by Hooper & McDonald, 2000), and DDT. PCBs, used in transformers as hydraulic fluid and as a lubricant, and DDT, a pesticide, are both now banned for most uses in the U.S. Whereas PCB can be measured directly, DDT is metabolized to DDE, which is the form that is most often measured in tissues. PBDEs are a family of chemicals used as flame retardants in plastics, foams, and textiles. POPs have been associated with reproductive and developmental toxicity, cancer, immune system suppression, and other types of dysfunction. They are long-lived chemicals, with half-lives averaging between two and 10 years in animals and up to 75 years in the environment. Half-life refers to the time it takes for the concentration of a chemical to decrease by 50 percent. As a result, they readily accumulate in the fatty tissues of both animals and humans. Because of their toxicity and environmental persistence, they have the potential to cause significant harm to aquatic animals.

Most organic contaminants, including POPs, accumulate in the sediments of coastal and ocean waters. Seals, as predators within the coastal food web, consume smaller aquatic organisms, especially those that live in sediment. These contaminants bioaccumulate in seals, making their levels in tissue a good indicator for POPs in the coastal/marine ecosystem. This indicator alerts us to the presence of POPs, but does not provide information about its effect on the health of seals or the aquatic ecosystem as a whole.

What factors influence this indicator?

The dramatic increase in the levels of PBDEs over the ten-year monitoring period may be associated with the documented global increase in production and use of PBDEs; however, no specific data exist for the Bay Area. These chemicals increased from 55 nanograms/gram fat tissue to over 3000 ng/gram fat over the 12-year monitoring period. The pattern observed in San Francisco Bay varies from what has been observed in other places around the world. In most cases, PCBs and DDT metabolites (DDE and others) are no longer increasing but are nonetheless 10 - 500 fold higher than PBDEs (Hooper & McDonald, 2000). PBDEs are used widely today and may cause many of the same harmful effects as the other POPs (Darnerud et al., 2001). In other parts of the world, control measures have resulted in curbing PBDE body burdens in marine mammals, yet no comparable controls are presently in place in the U.S.

Although banned, the increase in PCB levels in seal blubber probably reflects their long-lived nature; they are known to persist in and be released from the sediment for 75 years or more. Similarly, one might expect DDE levels to decline in seal blubber since it has also been banned. The fact that the DDE levels have remained stable over the past ten years indicates that, like PCBs, the sediment still retains small quantities that are passed through the food chain to seals.

Technical Considerations:

Data are presented on a logarithmic scale. The log scale was used to allow for the presentation of concentration data in a smaller sized graph. Beach-cast harbor seals are tracked by the University of California at Berkeley Museum of Vertebrate Zoology and the Marine Mammal Center. Field personnel examine the seals and obtain specimens for analysis, conducted by the Department of Toxic Substances Control's (DTSC) Hazardous Materials Laboratory. Biometric and chemical data are compiled in a database maintained by DTSC.

These data are powerful at examining trends and the study design allows for additional chemicals of emerging concern to be added, if needed. The limitation is the limited number of individual seals tested and the lack of stable funding and commitment for the field and laboratory work. To date, sample collection has been limited to San Francisco Bay seals, but the methodology is applicable to other coastal regions. In the future, analysis of seals at various points along the California coast would provide a better indication of ambient conditions all along the coast.

References:

Darnerud., P.O., G.S. Eriksen, T. Jóhannesson, P.B. Larsen, and M. Viluksela, 2001. *Polybrominated diphenyl ethers: occurrence, dietary exposure, and toxicology*. Env. Health Persp., 109 (Suppl 1): 49-68.

Hooper, K., and T.A. McDonald, 2000. *The PBDEs: An emerging environmental challenge and another reason for breast-milk monitoring programs*. Env. Health Perspect. 108: 387-392.

She, J., M.X. Petreas, J. Winkler, P. Visita, M. McKinney, and D. Kopec, 2001. *Polybrominated diphenyl ethers (PBDEs) In the San Francisco Bay Area: Measurements in harbor seal blubber and human breast adipose tissue*. Chemosphere, In press.

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Endocrine-Disrupting Chemicals in Aquatic Ecosystems

Type III

Endocrine disruptors are chemicals that interfere with the action of hormones, natural chemicals that control many functions within an organism. One major class of endocrine disrupting chemicals (EDC) are xenoestrogens, those that mimic the action of estrogen, a key female sex hormone. Xenoestrogens can inhibit the normal development of male sexual structures in aquatic animals and stimulate the growth of female sexual organs and tissues. Effluent from wastewater treatment plants is known to contain chemicals that are xenoestrogens, specifically, ethinyl estradiol, a breakdown product of the estrogen in birth control pills. Xenoestrogens, in the concentrations present in effluent, might cause sexual changes in fish. A recent report on salmon in the Columbia River found that 85 percent of the females were genetically male, suggesting sex alteration had occurred that could impair reproduction, although water chemistry analysis was not performed (Nagler et al., 2001). Similar results have been reported for salmon in a number of California rivers as well (Williamson et al., 2001). It remains to be seen if EDCs or other environmental disturbances are responsible for this phenomenon.

At present, no regular monitoring is conducted in California for the presence of EDC in wastewater treatment plant effluent. There is a need for biological and/or chemical monitoring in the rivers of the state, especially those that are home to threatened or endangered species. Future indicators should address this important issue.

References:

Nagler, J.J., J. Bouma, G.H. Thorgaard, and D.D. Dauble. 2001. *High incidence of a male-specific genetic marker in phenotypic female Chinook salmon from the Columbia River*. Env. Health Perspect. 109: 67-69.

Williamson, K.S. and B. May, 2001. *Sex-reversal of male chinook salmon (Oncorhynchus tshawytscha) in the Central Valley*. Abstracts, Coastwide Salmonid Genetics Meeting, Bodega Bay, CA.

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Issue 3: Desert Ecosystem Health

The Mojave and Colorado deserts of southern California occupy an area of just under 25 million acres, about 25 percent of the state's land. Deserts contain unique plant and animal communities that have evolved to survive in extreme conditions. Strong sunlight, high temperatures, low soil fertility, and little rainfall allow the survival of only those species that can withstand and succeed under such conditions. Compared with more temperate ecosystems, the desert has relatively low diversity of plants and animals. Soils are fragile, and activities that disturb soil crusts and remove vegetation quickly bring about wind and water erosion. Because of the extreme conditions in the desert and unlike other ecosystems within the state, recovery from human impact takes decades, even centuries.

Indicator

Status of the desert tortoise population (Type I)

Sub-issue 3.1: Alteration in biological communities

The degradation of habitat quality has led to the loss of native plants and plant communities and has increased the opportunities for non-native and invasive species. Nitrogen oxides (NO_x) blown in from the Los Angeles and Riverside air basins as well as off-highway and military vehicles and automobiles have increased the nitrogen content of the soil. Since nitrogen is one key limiting factor for plants in the desert, the higher level of soil nitrogen has allowed many exotic annuals and grasses to become established in the deserts, competing with native annuals there. The increased biomass then leads to an increased frequency of fires and changes in the biological communities of the desert. It has been suggested that changes in the plant communities might be one factor related to the decline in the population of desert tortoise, a threatened and endangered species.

Indicator

Impacts of off-highway vehicles on the desert (Type II)

Sub-Issue 3.2: Habitat degradation

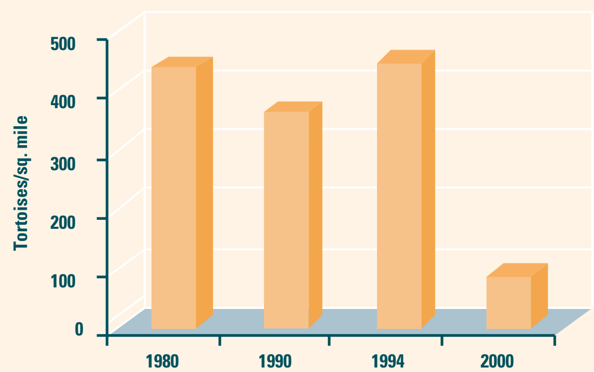
Military activities, off-road vehicles, and grazing compress the soil and destroy vegetation that stabilizes the surface of the soil and sand and provides food and habitat for animals. Compaction increases erosion and reduces the infiltration of water into soils. Fewer plants succeed and reproduce in compacted or disturbed soils. Recovery in desert ecosystems occurs much more slowly than in locations with more precipitation, i.e., decades and centuries in contrast to months and years. The disruption caused by off-highway vehicles is one of the important anthropogenic stressors on desert ecosystems.

Status of the Desert Tortoise Population

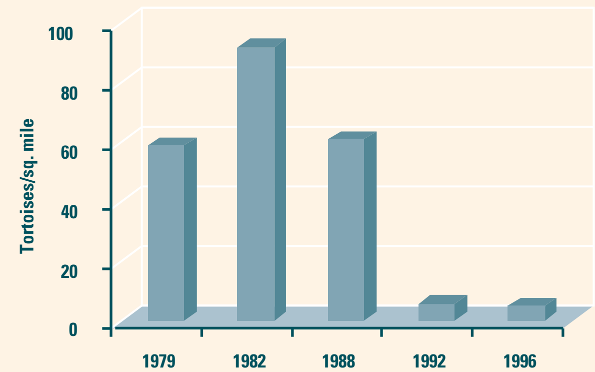
Desert tortoises are sensitive to environmental stressors.

Type I

Level 6
Goal 6



Source: Berry, 2000



Source: Brown et al., 1999

What is the indicator showing?

Desert tortoise populations, based on data from two study plots, have declined substantially in the past decade due to a wide variety of causes.

Why is this indicator important?

The U.S. government treats the desert tortoise as an indicator to measure the health and well being of the desert ecosystem. The tortoise functions well as an indicator because it is long-lived, takes 12-20 years to reach reproductive maturity, and is sensitive to changes in the environment (Berry & Medica, 1995).

Desert tortoise populations have declined dramatically because of human and disease-induced mortality, as well as destruction, degradation, and fragmentation of their habitat. As of 2002, there are no stable or increasing populations of tortoise in areas designated as "critical habitat" by the U.S. Fish and Wildlife Service. The health of the tortoise population reflects on the overall health of the desert ecosystem.

What factors influence this indicator?

The U.S. Fish and Wildlife Service (USFWS) listed the desert tortoise as a threatened species in 1990. The tortoise's range includes parts of the Mojave, Colorado, and Sonora Deserts. In California, 27 permanent desert tortoise study plots were established between 1971 and 1980. During this time, high mortality rates were documented in some parts of the desert from illegal collecting, road kills on highways and from off-road vehicle use, raven predation, and shooting. Habitat deteriorated or was lost due to urban and agricultural development, roads, freeways, pipeline and transmission line corridors, mining, livestock grazing, and fires. During the 1990s, diseases and invasions of alien plants have been added to the list of problems (Brown et al., 1999).

Between 1979-1980 and 1989-1990, tortoise populations in the western and southern Mojave Desert and the eastern Colorado Desert declined primarily due to human activities. Declines on some study plots ranged from 30 to 90 percent. At the time of listing, the population at the Goff's study plot in Fenner Valley, Eastern Mojave, was considered "the Gold Standard" for a stable population. Tortoise populations on two other plots in the Ward and Chemehuevi Valleys in the Colorado Desert, located in southeast California, were increasing between 1979 and 1990 (Berry, 1999). Populations plummeted at the Goff's and Chemehuevi Valley plots in the late 1990s. (Berry, 1999, 2000) Numbers of adult tortoises found on the plots declined 84 percent at Chemehuevi Valley between 1992 and 1999, while the number of tortoises found on Goff's plot in 2000 declined roughly 90 percent from earlier surveys.

Most recently, populations of tortoises appear to be dying of upper respiratory tract disease, shell disease, and elevated levels of several elements such as arsenic. Additional research is underway to understand the population declines. Shell diseases appear to be associated with toxic elements, such as arsenic and/or nutritional deficiencies. Identification of the most important factors affecting the tortoise population is key to its recovery.

Technical Considerations:

Data Characteristics

A Recovery Plan for the Mojave Desert Tortoise population was prepared in 1994. As part of the Recovery Plan, USFWS is coordinating the efforts of several federal and state agencies to estimate current tortoise population densities. This information will be developed over the next 3-5 years by sampling selected transects of the desert. After the baseline population density is established, the same transects will be monitored every three to five years to determine changes in the tortoise population densities. This is the first year (2002) of line distance sampling throughout the desert tortoise critical habitat within the Mojave Desert. Data has also been collected by the U.S. Geological Survey (USGS) in relatively small study areas.

Strengths and Limitations of the Data

In recent years, population density surveys at the permanent study plots have not been conducted on a regular basis due to lack of funding. Prior to 1994, plots were surveyed at average intervals of four years. Between 1995 and 2001, surveys at the 15 baseline study plots were limited due to lack of federal funding. Since 1995 only five plots have been surveyed, two of which were conducted with funds from outside the USGS or the Bureau of Land Management (BLM). In 2002, the California Department of Fish and Game will support surveys of four plots through the USGS, and BLM plans to contribute funds for additional work. Valuable information is lost by the longer intervals, making it harder to understand the causes of disease and population changes (Berry, 1999).

References:

Berry, K.H. 2000. *Preliminary report on the spring survey of desert tortoises at the Goff's permanent plot and special project of effects of roads.* USGS, Riverside California.

Berry, K.H. 1999. *Preliminary Report from the 1999 Spring Survey of the Desert Tortoise Long-Term Study Plot in Chemehuevi Valley and Wash, California.* Unpublished report provided by the author, Station Manager of the USGS Western Ecological Research Center, Riverside, CA.

Berry, K.H., and P. Medica, 1995. *Desert Tortoises in the Mojave and Colorado Deserts, Our Living Resources*. (Edward T. LaRoe, ed.) U.S. Department of the Interior, National Biological Service, Washington, D.C.

Brown, M.B., K.H. Berry, I.M. Schumacher, K.A. Nagy, M.M. Christopher, and P.A. Klein. 1999. *Seroepidemiology of upper respiratory tract disease in the desert tortoise of California*. J. Wildlife diseases 35: 716-727.

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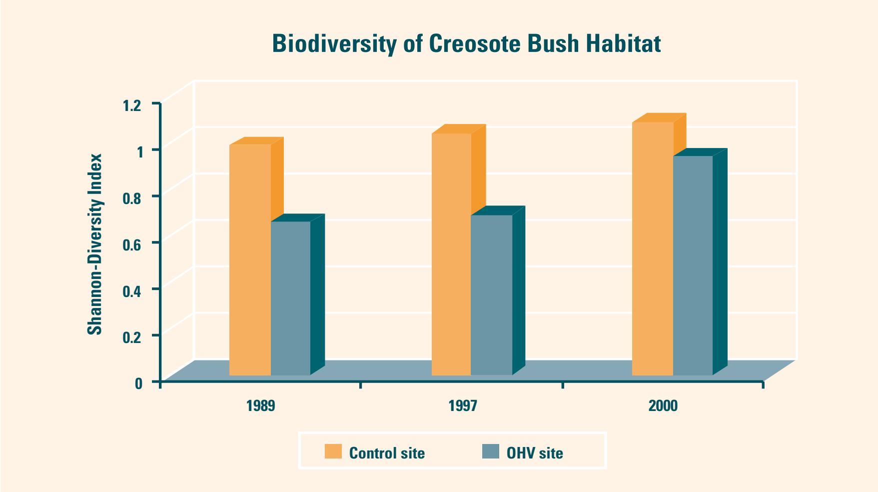
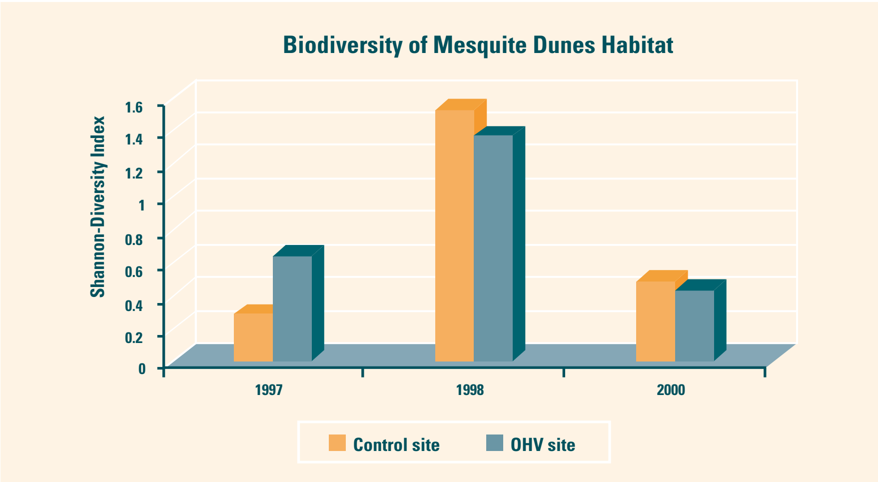
Impacts of Off-Highway Vehicles on the Desert

Type II





What is the indicator showing?

In creosote bush habitat, off-highway vehicle (OHV) use has decreased plant diversity. In contrast, in mesquite dunes habitat, plant species diversity is similar at the OHV and control study sites. Differences in moisture content of the soil and regeneration time of vegetation in the two habitats are some of the factors that contribute to this disparity.

Why is this indicator important?

The California Department of Parks and Recreation monitors the impact of off-highway vehicles (OHV) on vegetation and wildlife species diversity in all State Vehicular Recreation Areas (SVRA). In 1991, the Department of Parks and Recreation initiated a monitoring program to assess the impacts of OHVs on vegetation and animals (ohv.parks.ca.gov). The Shannon Diversity Index (SDI) is used to measure biodiversity by calculating the ratio of the number of each type of species relative to all species within the "monitored area." A higher Shannon's Diversity Index value indicates greater species diversity. Data are being collected on mammals, reptiles, and birds as well as vegetation. At present, there are sufficient data for interpretation only for vegetation. In future years, information on animals will be presented in an updated report.

What factors influence this indicator?

Off-road vehicle use is one of the major recreational activities in the deserts of California. In a number of different ways, OHVs can negatively impact the desert. OHV use can compact soil, damage or destroy plants, reduce water infiltration, increase wind and water erosion, and produce intense noise. OHVs are also one source of ambient nitrogen oxides, which have been correlated with increased soil nitrogen deposition and the accompanying increase in exotic plant species. All of these stressors have the potential to adversely affect the desert ecosystem. Since recovery from these impacts is much slower in the desert than elsewhere, it is important to detect changes as early as possible.

Comparison between the creosote bush and mesquite dune habitats suggests that OHVs may affect the former more than the latter. Three possibilities account for this disparity. First, there may be less wind scouring and desiccation in mesquite habitat, leading to higher moisture content of the soil. Higher moisture content facilitates growth of vegetation. Second, hardpan, hard compacted soil, is more prevalent in creosote bush habitat. It is more difficult for plants to become established in hardpan compared to other types of soils. Third, creosote bushes produce chemicals that can inhibit the growth of other nearby plants. These factors as well as others contribute to the poor ability of plants to regenerate in those OHV-areas dominated by creosote bush when compared to mesquite dunes. We need to gain a better understanding of the influence of these and other factors on the ability of vegetation to regenerate in OHV-use areas.

References:

California Department of Parks and Recreation, OHV website: ohv.parks.ca.gov

For information on the development of the U.S. Bureau of Land Management's new OHV plan to protect the environment, see their website: www.blm.gov/ohv.

An analysis of the plan by the Wilderness Society is posted at: www.wilderness.org/standbylands/orv/blm_strategy.htm.

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Distribution of Exotic Plants

Type III

Exotic plant species are spreading throughout the desert as a result of a variety of anthropogenic stressors. The extent of exotic plant species could be developed as an indicator for health of the desert ecosystem. The effects of exotic plant species on productivity and diversity of desert habitat are under study. Although the number of exotic plant species in the desert is relatively small compared to other regions of California, those that have become established present a threat to the structure and function of native desert plant communities. Research has shown that as the biomass and extent of exotic plants increase, the diversity of native plant species declines to the detriment of the wildlife that relies on the native species. In addition, increasing amounts of exotic annual plants create a wildfire hazard that did not exist prior to these plants becoming established in the desert. This is a significant problem since regeneration time in the desert is exceptionally slow.

Red brome, schismus, and filaree, all non-natives, now account for the majority of the annual plant biomass in many areas of the California Mojave Desert. Fires are more frequent where the biomass of red brome is high, and fires have become more frequent since the invasion of red brome into the Mojave Desert region (Kemp & Brooks, 1998).

At this time, there are no systematic regional data showing the extent of invasive plants in California deserts. Various research projects are underway to determine the extent and effects of exotic plant species. The U.S. Geological Survey (USGS) has a Southwest Exotic Plant Mapping Program for Arizona, New Mexico, and the Colorado Plateau portions of Utah and Colorado. This project is developing and distributing information on exotic plant species distributions. If extended to include the California desert, this program could provide data for an indicator of the extent of invasive plant species. (Contact: Dr. Kathryn Thomas, Ecologist, USGS Forest Resources Ecosystem Science Center, (520) 556-7466 x 235; kathryn_a_thomas@usgs.gov).

Reference:

Kemp, P.R. and M.L. Brooks, 1998. *Exotic Species of California*. Fremontia, 26:4.

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Indicators

Change in habitat quantity in rangelands and forests (Type I)

Change in forest canopy (Type I)

Pest and disease related mortality in forests (Type I)

Wildfires in forests and grasslands (Type I)

Sustainability of California's forests (Type I)

Issue 4: Health of Forests, Shrub Land, and Grassland (Terrestrial) Ecosystems

Sub-issue 4.1: Habitat quality and quantity

Terrestrial habitat components include the abundance and configuration of landscapes, the presence of natural structural elements, and the fertility of soil. These components define a habitat's ability to support biodiversity, productivity, and overall habitat quality. As habitats change, disturbances associated with air pollution, fire, flood, harvesting, and development result in changes to forest size, age, density, spatial arrangement of trees and openings, soil organic matter, and loss of structural components such as snags and downed logs.

Habitat loss from agricultural conversion and urbanization reduces the ability of ecosystems to provide food and cover to animals. Interruption of ecological processes is the precursor to reduction of long-term sustainability and biological diversity.

The indicators to evaluate the status of forest habitat are listed in the box above. Habitat quantity is a direct measure of total acreage in the state. One factor used to assess habitat quality is canopy cover. Pests, disease, and wildfires are the major stressors on the forests and their impacts are reflected in the indicators. Finally, the relationship between growth and harvest of trees is used to assess the sustainability of forest lands.

Indicators

Status of Northern Spotted Owl (Type II)

Status of amphibian populations (Type III)

Ozone injury to pine peedles (Type III)

Sub-issue 4.2: Loss of biodiversity

Biological diversity is defined as the variety and variability of living organisms and the ecological complexes in which they occur. The state's diverse topography, soils, geographic position, and climate contribute to a wide range of terrestrial habitats and plant and animal species, many of which are unique to California. Our rich resource base, pleasant climate, and economy have also attracted a large and growing population, impacting the state's biodiversity. The two major stressors on terrestrial biodiversity are a) conversion of habitat due to urban, suburban, and agricultural/forestry/range use, and b) introduction of non-native species. Conflicts between human activities and conservation of the state's biological wealth can be expected to escalate and will provide future conservation challenges.

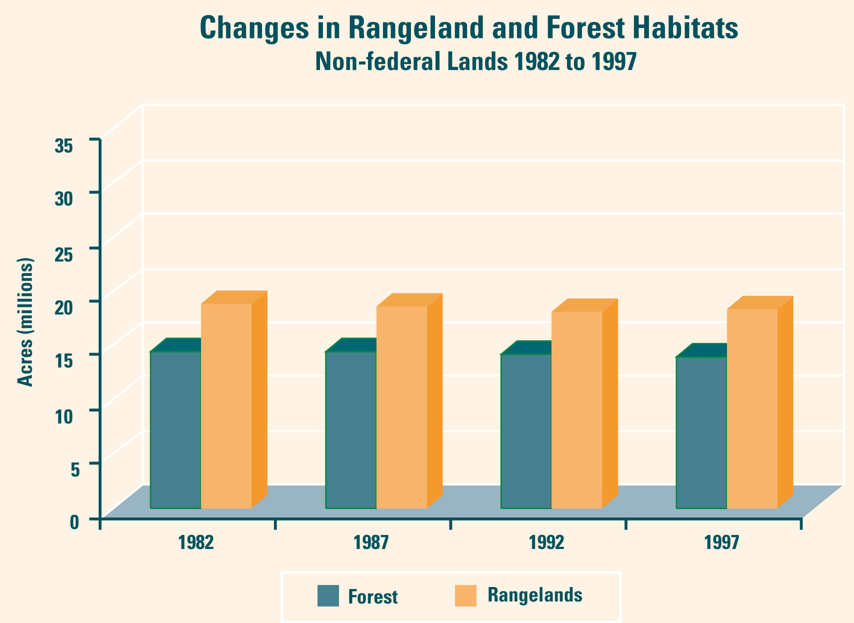
Spotted owl status was selected as an indicator of biodiversity because this owl is on the state and federal threatened and endangered species list and is highly sensitive to alterations in habitat. The status of amphibian populations is an issue of emerging concern due to widespread reports of deformities and declines in populations of frogs. Ozone effects on pine needles was also included as an indicator because it clearly links ambient air pollutants regulated by the state to damage of a valued natural resource.

Change in Habitat Quantity in Rangelands and Forests

Losses in acreage of rangeland and forest habitats from 1982 to 1997.

Type I

Level 6
Goal 4, 6



What is the indicator showing?

Approximately 1.2 million acres (from 33.4 million acres in 1982 to 33.2 million acres in 1997) of range and forest habitats on private land were converted to other uses or transferred to public ownership.

Why is this indicator important?

The indicator tracks private rangelands and forests to monitor changes in the loss of natural vegetation that exist on most range and forest lands. Compared to more intensive land uses (agriculture, urban), private range and forest systems contain a greater amount of natural vegetation, wildlife habitats, and less alterations of water quality.

What factors influence this indicator?

Private range and forest habitats decreased by approximately 1.2 million acres from 1982 to 1997 at an average rate of 79,000 acres per year. While some of this land went into federal ownership, the remainder of the total decrease represents a shift to residential uses, commercial development and irrigated agriculture. Several observations regarding the change in range and forest land area can be made:

- Over 930,000 acres of range and forest land were converted to “developed land” or “other rural land,” categories which describe urbanization.
- 618,00 acres of private range and forest land were transferred to federal ownership, where the natural habitat characteristics of the land are likely maintained.

- Rangeland and agricultural land have had substantial exchanges during the period resulting in a net gain of over 365,000 acres of rangeland from agricultural land (Cropland and Pastureland).

Most of the changes within the private forest area measured by the National Resources Inventory (NRI) are outside of the productive forest land capable of being managed for timber production. While private productive timberlands represent about 25 percent the private rangeland and forest land base, only 10 percent of the annual loss comes from productive timberlands. Of the total annual loss of all range and forest area of 79,000 acres per year, productive timberlands losses average about 7,600 acres per year during the same period.

Technical Considerations:

Data Characteristics

Methods for data collection have been established since 1982 between the Natural Resources Conservation Service and Iowa State University. The National Resources Inventory is the source used to derive this indicator. This source uses a fixed plot point sampling system to revisit periodically the same site to monitor the status of the land base. The primary plot size is 160 acres with a sampling rate of approximately 2 to 6 percent of the sampling area.

Strengths and Limitations of the Data

Data used to construct this indicator are limited to the broad definitions of forest and rangelands provided by National Resources Inventory. Specific habitats within these broad categories are not discussed. Additionally, no information is publicly available to better identify lands at greatest risk for conversions.

References:

Natural Resources Conservation Service. *Summary Report, 1997 National Resources Inventory*. Revised December 2000. Posted at: www.nhq.nrcs.usda.gov/NRI/1997/summary_report/original/contents.html

Pacific Northwest Research Station, Forest Inventory and Analysis Program www.fs.fed.us/pnw/fia/

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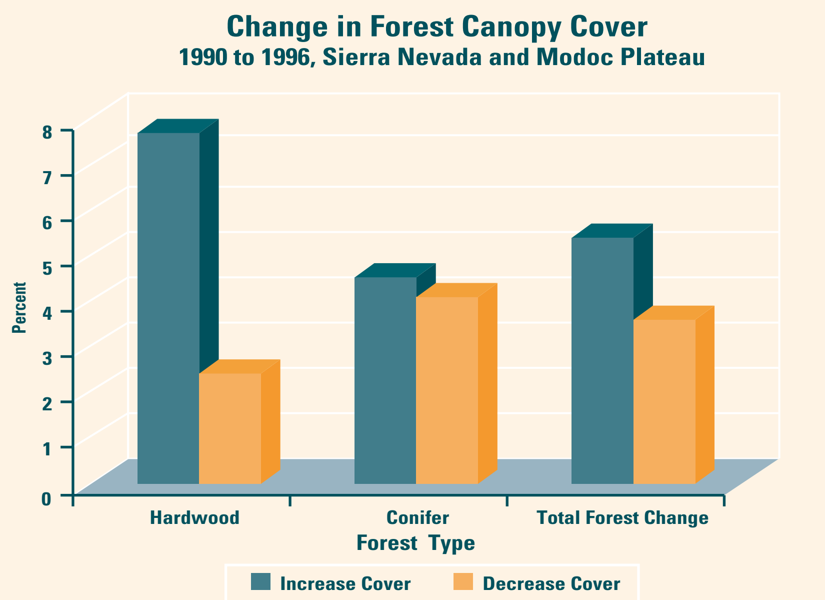
Change In Forest Canopy

Forest ecosystems show dynamic changes in canopy cover in the Sierra Nevada and Modoc Plateau from 1990 to 1996.

Type I

Level 6
Goal 6



What is the indicator showing?

Increases in canopy cover in two major California forest regions exceeded decreases in canopy cover. The increases are primarily due to regrowth of young forests. In contrast, decreases are occurring in forests of all ages, spanning the range from young to very old forests. The substantial increases in hardwood relative to conifer canopy cover are due to regrowth in past fire areas.

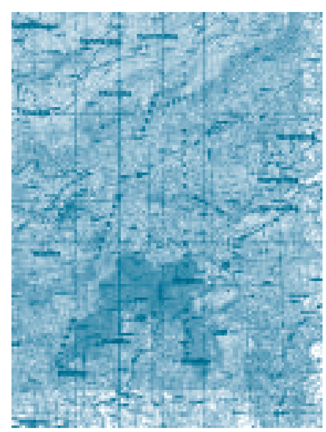
Why is the indicator important?

Forest cover, or the horizontal area that trees occupy, is both biologically important and affects human value of forest ecosystems. It describes the continuity and density of tree vegetation on the landscape. Alterations in forest cover changes the mix of age classes and can have both positive and negative effects on wildlife habitat, fire conditions, aesthetics, productive capacity, economic value and air quality change.

Forests are always in a dynamic state of change as younger trees grow to occupy gaps within forests. As forests grow, trees are lost due to mortality, fire, harvest, and development. Identifying the spatial patterns of these changes requires analysis of the change of canopy cover between two time periods. The figure illustrates a detailed map of changes developed from a comparison of two satellite images taken 5 years apart as part of a statewide assessment of changes in vegetation. This analysis accurately captures the area and causes of changes in total vegetative canopy cover, but not the changes in total biomass.

For the combined region encompassing the Sierra Nevada and the Modoc Plateau to the north, more than 90 percent of all forest areas showed no change in forest canopy between 1990 and 1996. Approximately five percent of the area showed an increase in canopy cover while another four percent showed a decrease.

Change in Forest Canopy Map

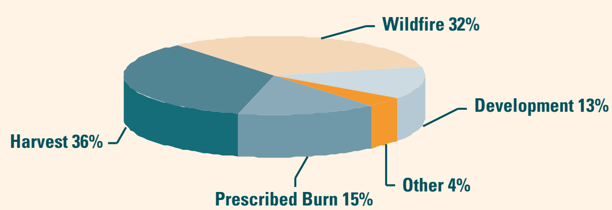


See full color map on page 257

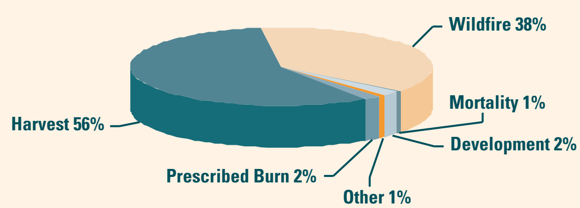
What factors influence this indicator?

On the 16.1 million acres of conifer and hardwood forests in these regions, increases in canopy coverage exceeded decreases in canopy coverage (875,000 vs. 582,000 acres) between 1990 and 1996. Increases are attributable to normal growth patterns or rapid regeneration after fires or harvesting in the previous period and are primarily found in small tree size classes. Decreased canopy cover is attributable to human intervention (harvesting and development) as well as natural events (wildfire and pest damage). With the exception of permanent land conversions, the re-growth of the forests through the sequence of seral stages will begin on these sites. The spatial identification of where these patterns are occurring allows for a more detailed analysis of what is driving these changes in forest seral stages in different areas around the state. See pie charts below:

Hardwood Forest Canopy Decreases by Cause
Modoc and Sierra Bioregions, 1990 to 1996



Conifer Forest Canopy Decreases by Cause
Modoc and Sierra Bioregions, 1990 to 1996



Lands that experienced large decreases in canopy cover (greater than 70 percent canopy cover reduction) are a particular concern. While a variety of mosaics of opening are sustainable, these types of decreases usually represent long-term or permanent shifts in habitat type (e.g., major fires that completely replace forests and development). More than 41,000 acres of conifer forests and 5000 acres of hardwood forests had large decreases in canopy cover.

Technical Considerations:

Data Characteristics

Multi-date Landsat TM imagery provides the base data. The data covers all major forests and rangelands (excluding desert) and monitors over 65 percent of the land base of the state. Three classes of vegetative change are assessed for increases and decreases: large, moderate and small. Additionally, a no-slight change class is monitored.

Strengths and Limitations of the Data

Data of this type have a number of important strengths. First, information can be particularly relevant for watershed analysis, where site-specific impact information is needed. Second, data are used to update existing vegetation maps and to re-inventory permanent plots. Third, with data being spatially available within Geographic Information Systems, they can be combined with other data sets to interpret forest conditions that influence ecosystem management decisions.

A limitation to the data is the accuracy of interpretation of change. Vegetation increases in hardwoods or conifer canopy do not always represent canopy change, as seasonal variation due to vegetation moisture content may give an inaccurate reading. Additionally, not all monitored areas are assessed for the cause(s) of change.

References:

Chris Fischer, GIS Analyst, Fire and Resource Assessment Program (FRAP), California Department of Forestry; Lisa Levien, Remote Sensing Specialist, USDA Forest Service Remote Sensing Laboratory.

Fire and Resource Assessment Program (FRAP), California Department of Forestry; frap.cdf.ca.gov/projects/land_cover/monitoring/index.html

USDA Forest Service Remote Sensing Laboratory. www.r5.fs.fed.us/fpm/index.htm

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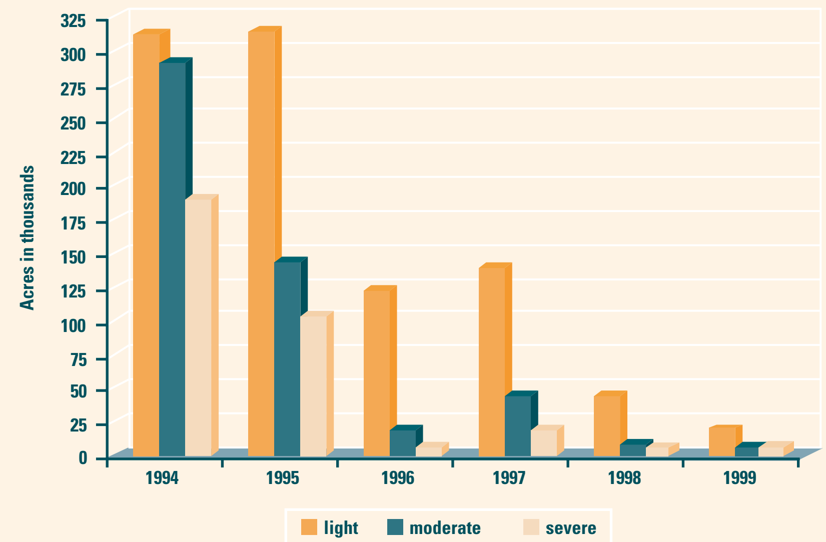
Type I

Level 6
Goal 4, 6

Pest And Disease Related Mortality In Forests

Tree mortality in California's public forests has been decreasing since 1994.



What is the indicator showing?

The acres of federal and adjacent private forest land where tree mortality has occurred have decreased from very high levels in 1994 to relatively low levels in 1999.

Why is this indicator important?

Forest insects and diseases often shape California's forests at basic levels with cyclical outbreaks. With historic information suggesting that mortality typically affects one percent of the forest land base annually, peak levels seen in 1994 affected nearly five percent of the surveyed forest land base. By 1999, mortality had dropped below the long-term average of one percent. The desired state of forest health, in relation to insects and disease, is the condition in which these agents do not seriously threaten ecosystem structure and function on a continuous basis. At low levels, insects and disease provide a necessary role through pollination, nutrient cycling and thinning of weakened and stressed trees. Fire suppression, grazing and logging activities have combined with natural ecosystem processes to create overly dense stands of trees and have altered the mix of vegetative species. This alteration of conditions has resulted in an increase in susceptibility to insects, disease and weather-induced stresses. Non-native pests also play a major role in altering conditions and contributing to forest mortality. These changes can reduce the quality of habitat for wildlife.

Statewide Mortality
1994-1999, Based on Aerial Surveys

See full color map on page 258

What factors influence this indicator?

Observable mortality in forest ecosystems is a cyclical event due to a combination of native pest agents, pollution, human management, wildfire, stand conditions, introduced pests and climatic conditions. The high levels of conifer mortality observed during the early 1990s have declined dramatically since 1994. The mortality was caused by bark and fir engraver beetles in concert with overstocked stand conditions, altered species compositions and the protracted drought between 1987 and 1991. Acres of mortality on surveyed forestlands dropped from 809,000 in 1994 to 33,000 in 1999. The damage during the late 1980s to 1994 represented a peak in the cyclical pattern of damage to California forests.

Technical Considerations:

Data Characteristics

The data are collected as part of the National Forest Health Monitoring Program, which is a cooperative state and federal program to annually survey for the conditions of the federal forests. Results summarized here are for the aerial survey portion of the monitoring program. Data collected from aerial surveys are further classified by the severity of change; the percent mortality is identified in polygons circle on a map. Mortality is then classified as lands with greater than 11 percent mortality (severe), 6-10 percent mortality (moderate), and 0-5 percent mortality (light). Over 80 percent of the observed mortality was in the light and moderate categories.

Strengths and Limitations of the Data

The aerial survey used to determine mortality was limited to national forest lands and other public lands. Private lands were not the major focus of this survey. Of the over 36 million acres of forest land base in the state, approximately 22.5 million acres were surveyed in 1999.

References:

California Forest Health, U.S.D.A.; Forest Health in the West Coast, Cooperative U.S.D.A. and Oregon Department of Forestry; Forest Pest Conditions in California, the Forest Pest Council.

Timber Resource Statistics for the Resource Areas of California, 1994 and 1997, Waddel and Bassest. PNW- RB 214, 220, 221, 222, 224. www.r5.fs.fed.us/fpm/fhp_doc.htm.

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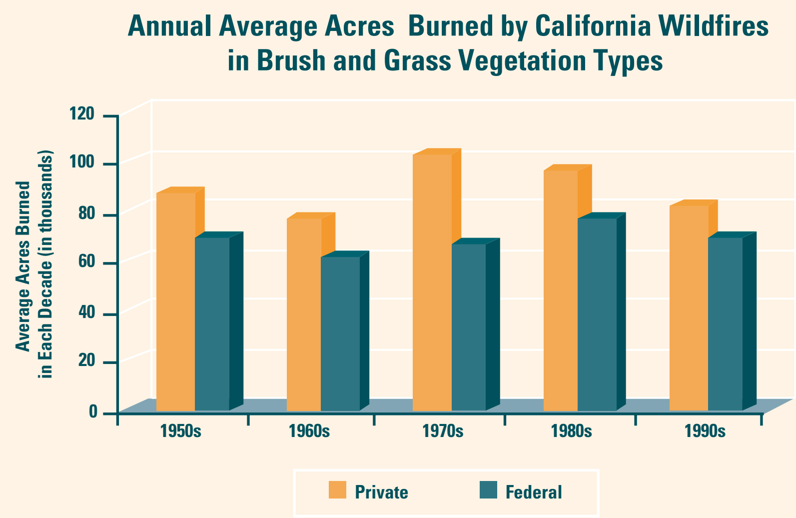
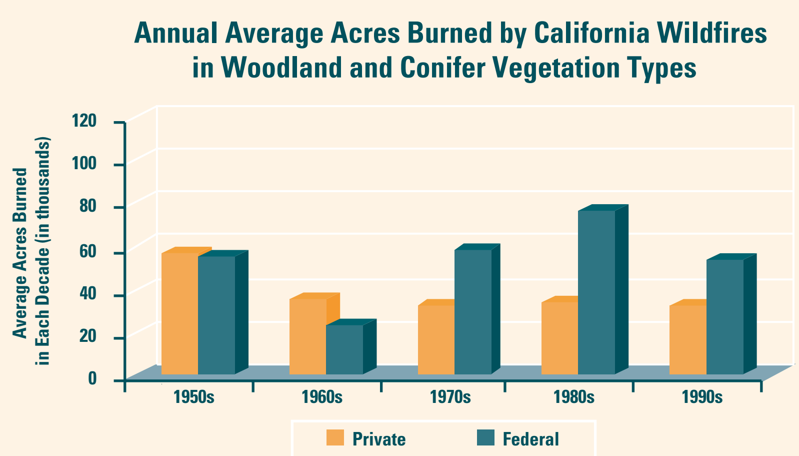
Type I

Level 6
Goal 6

Wildfires in Forests and Grasslands

Average acres burned by wildfires have been relatively constant except for an increasing trend on federal woodland and conifer forests.





What is this indicator showing?

Over five decades, wildfires in brush and grass types are more common than wildfire in forested areas.

Why is this indicator important?

By reviewing the number of acres burned over time, public land managers and persons concerned with natural resources on private lands may spot trends in the rate of wildfire occurrence. Such information may help these managers better understand the potential for impacts on ecosystem health. This indicator presents wildfire acreage information across different vegetation types and ownerships based on data collected from reports covering the period 1950 to 1997. As such, it is a broad and general indicator based the summary of past fire occurrences.

What factors influence this indicator?

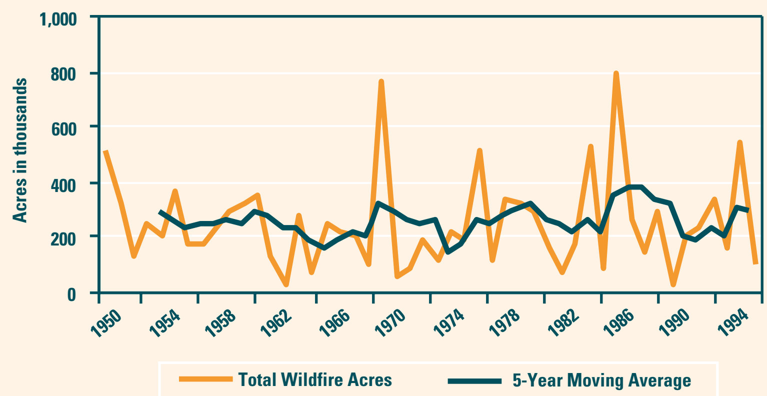
Characteristics of individual fires, and their ecological and economic impact, depend on a number of factors including local fuel conditions, weather, topography, accessibility, availability of fire suppression resources, and suppression policies. The indicator does not discriminate as to the extent of area burned at ecologically destructive levels. Thus, we assume no systematic change in the average severity of fires (e.g., frequency of stand replacement). While wildland fire has been shaping California's landscapes for eons, the modern era has had substantially fewer fires compared to the period before European settlement. An average of approximately 200,000 acres burn each year, but year-to-year variability in acres burned is quite high. California's Mediterranean climate produces extensive areas with flammable vegetation. The dry summers drive down fuel moisture, and high winds can quickly turn an ignition into a serious fire leading to resource damage and loss of property, and sometimes lives as well.

Yet fire performs important work for ecological health. Ecologically, fire helps to shape the spatial structure and composition of vegetative cover, provides for nutrient cycling, and triggers changes needed to maintain natural ecosystem functions. Vegetation dynamics are significantly driven by an ecosystem's fire regime, which is the frequency and nature of fire in that system. Where modern era fire regimes are significantly different from those that the ecosystem evolved under, ecosystem health is jeopardized. An example of such a problem has occurred in forested types that evolved under frequent, low severity fire regimes. The modern era has extended fire frequencies allowing unnatural fuel accumulations that then result in high intensity fires, which burn through forest canopies and kill most or all trees, and cause high levels of soil damage. To enhance ecological health in these systems, the restoration of more frequent, lower intensity fires is needed.

Brush and grass ecosystems are experiencing more acreage burned by wildfire than conifer and woodland ecosystems, especially on private lands. The acreage of affected brush and grasslands is nearly the same as the forests, but brush and grass ecosystems generally burn more often and are predominantly in private ownership. They may have a higher propensity to burn because of the longer fire season in these areas, and because they are finer and more wind-exposed fuels that ignite and carry fire more readily. They also rapidly re-accumulate flammable fuels after a fire, and they have a greater spread rate, which challenges the initial fire suppression efforts.

Conifer and woodland ecosystems show a greater variation in area burned over time on public land as compared to private lands. This variation is probably a reflection of differences in the balance between natural forces and management efforts. Although stand-replacing fires occur on private as well as public lands, publicly-owned forests are often more remote and heavily wooded, with continuous canopy cover over large areas. Multiple lightning strikes across large expanses may quickly strain suppression resources available for initial attack. Accessibility problems and concerns about potential impacts from suppression resource often limit ground attack options. Thus, it is not surprising to see a greater volatility in the indicator as it applies to public lands.

Historical Wildfire in California, 1950 to 1997



The occurrence of years in which exceptionally large numbers of acres burn may be becoming more frequent. The wildfire pattern shown in the graph "Historical Wildfire In California, 1950 to 1997" suggests that since 1970, the number of fires that burned more than 500,000 acres appear to be increasing. Are these extreme fire seasons really becoming more frequent? Additional data may help clarify this important question.

Fire suppression efforts have changed ecosystem conditions and fire behavior. The fire perimeter data suggests that fire intervals (years between fires over a given area) have increased substantially throughout California woodland and conifer habitats. Historical fire intervals averaging ten years have now increased in some habitats to greater than 500 years. This increased interval is largely the result of fire suppression efforts. The ecological results of decreased fire frequency are:

- Composition shift to shade tolerant species
- Increased forest density (stocking)
- Increased susceptibility to beetle/insect infestation
- Increased surface and crown fuel hazard
- Increased tendency for the most devastating stand replacing fires and
- More receptive environments for invasive plant species in post fire habitats.

Additional information suggests that while the number of wildfires is within normal, cyclical ranges, the dollar values of assets destroyed by fire are rising significantly. Housing losses to wildfire have shown a large increase every decade over the last 50 years.

Technical Considerations:

Data Characteristics

The California Department of Forestry and Fire Protection (CDF), Fire and Resources Assessment Program (FRAP) and U.S. Forest Service (USFS) Region 5 Remote Sensing Lab are jointly developing a comprehensive fire perimeter Geographic Information System layer for public and private lands throughout the state.

The data initially included CDF fires 300 acres and greater in size and USFS fires ten acres and greater. The data includes most, but not all, fire perimeter data from other federal agencies (e.g., National Park Service, Bureau of Land Management, Bureau of Indian Affairs, Department of Defense) and local and county agencies. For official CDF fire statistics, refer to "Wildfire Activity Statistics", updated each year by CDF (Wildlife Activity Statistics, yearly). The analysis covers 47 years of fire data across 56 million acres of land. The earliest mapped fires recorded by CDF are from the year 1950; 1997 is the most recent year for which most areas in the state have data. Agricultural, desert, and urban areas are not included in the analysis. In addition, lands over 6,500 feet in altitude are excluded due the low prevalence of fires and the high proportion of areas that are either designated wilderness or non-roaded.

Strengths and Limitations of the Data

The fire perimeter data are continually under development and some fires may be missing altogether or have missing or incorrect attribute data.

References:

Fire and Resource Assessment Program (FRAP)
James Spero, james_spero@fire.ca.gov
Dave Sapsis, dave_sapsis@fire.ca.gov

Wildfire Activity Statistics, California Department of Forestry, published yearly.

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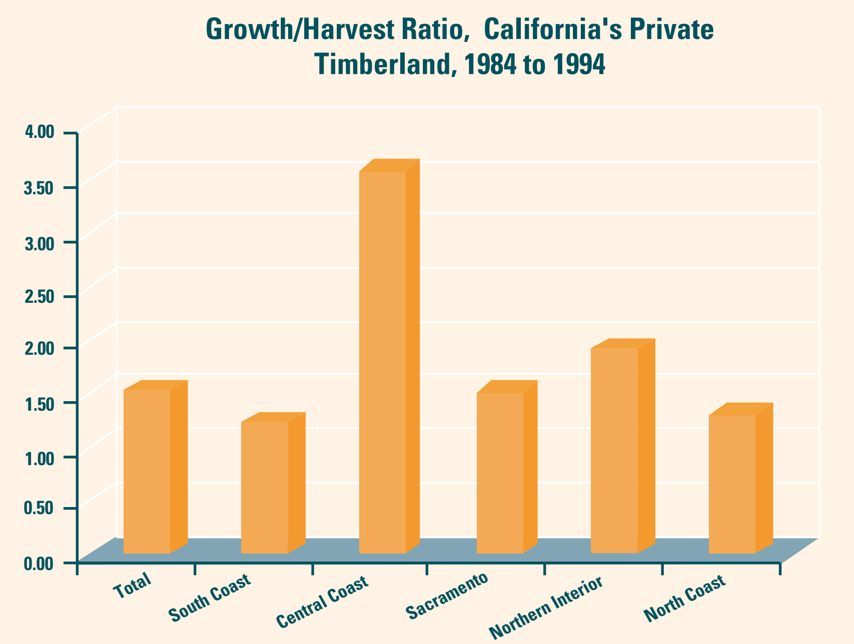
Type I

Level 4
Goal 6

Sustainability of California's forest

Growth on California's private timberlands exceeded harvest between 1984 and 1994.



What is the indicator showing?

On the State's private timberlands, growth is exceeding harvesting suggesting ecosystem processes are being maintained.

Why is this indicator important?

Long term sustainable forest management requires that forest growth exceed forest harvest, especially if there is a goal of increasing dense forest habitat. When growth exceeds harvest, several valuable ecological functions and habitat components of forested ecosystems are usually being sustained and often improved. Examples of wildlife habitat components that may be sustained include forest cover continuity and stands with larger trees. Additionally, watershed protection on a large scale will nearly always be greater if overall forest inventories are increasing. However, the relationship between increasing inventory and stable or better ecological conditions is not always proportional. Variation such as the spatial array of trees or the quantity and distribution of habitat elements in the forest (snags, down logs) is not captured by this indicator. Additionally, lack of harvesting can result in detrimental forest conditions, such as unnatural levels of fuel build-up in the absence of regular fire.

What factors influence this indicator?

This indicator compares the relationship of harvest to net growth of California's private forest lands in five different regions of the state. The indicator is developed by dividing total growth in millions of cubic feet (less total mortality) by the total cubic feet harvested.

Each region in the state has been classified as having productive land base on which growing and harvesting trees is a suitable practice. These lands are monitored every ten years to evaluate, among other things, tree growth, mortality (insect/disease/storm events), and the harvesting of trees. When comparing the results of these data in both conifer and hardwood forests, growth is 53 percent greater than harvest.

This indicator suggests that the state's forest ecosystems are producing more than the amount being harvested, indicating sustainable productivity conditions. Additionally, public lands with substantial forested ecosystems (Forest Service and National Parks) typically have very large growth levels that exceed harvest levels. If these data sets are combined, it is likely that forest growth substantially exceeds harvests in California.

Technical Considerations:

Data Characteristics

The data are collected as part of the U.S. Department of Agriculture, Forest Service (USFS), Pacific Northwest Research Station period forest inventory analysis. This is a national program conducted annually by the USFS and reported on 10-year intervals. The information is reported pursuant to the Forest and Rangeland Renewable Resource Research Act of 1978. Data are collected from fixed-plot ground-based sampling.

Strengths and Limitations of the Data

Additional information is available to describe growth/harvest on land owned by private groups (forest industry and other private owners). Certain regions, such as the North Coast where the majority of timberlands are found, may show different patterns of growth/harvest when separately reviewed. This indicator is only one of a suite which characterizes the conditions of ecosystem health of forest and rangeland habitats. When reviewed with other indicators, a more complete understanding of forest health conditions can be gained.

References:

Timber Resource Statistics for the Resource Areas of California, 1994 and 1997, Waddel and Bassest. PNW- RB 214, 220, 221, 222, 224.
www.fs.fed.us/pnw/fia/

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Type II

What is this indicator showing?

According to a recent survey by the U.S. Geological Survey (USGS), moderately sized populations of spotted owls still exist. The number of known or suspected pairs is 2,300 in California, 2,900 in Oregon, 860 in Washington, and 30 in British Columbia. Trends from models using research data indicate that populations are declining, primarily the result of low survival of adult female owls.

Status of Northern Spotted Owl

Why is this indicator important?

In 1990, the federal government placed the northern spotted owl on the list of threatened species. This indicator is presented separately from the 'California Threatened and Endangered Species' indicator because it has been the centerpiece of debate regarding forest management on federal lands in the Pacific Northwest. The northern spotted owl inhabits the forests of the Pacific Coast region from southwestern British Columbia to central California and has an apparent preference for large tracts of old growth forest. Logging of old growth forests on federal land has been dramatically reduced in an effort to protect the spotted owl and its habitat, with severe economic consequences for timber-dependent communities in California, Oregon, and Washington.

What factors influence this indicator?

These are the only birds on the federal list of threatened and endangered species that occupy mature conifer forests. These forests are a dwindling resource, particularly coastal old-growth redwood forests. A federal study of species associated with old-growth forest listed 38 bird species. The U.S. Geological Survey (USGS) Breeding Bird survey shows downward trends for the population of 12 of these species; none of the 38 species shows an upward population trend.

More is known about the distribution and abundance of the spotted owl than about any other owl, but the status of the species is still hotly debated. In addition to habitat lost, population assessments are affected by weather, long-term population cycles, ratios of core to edge habitat, and survivorship to reproductive age. Further it appears that spotted owls respond differently to forest management practices in different regions of California and the Pacific Northwest. In some portions of northern California, for example, spotted owls are relatively common in redwood forests aged 60-100 years. However, few owls occur in such forests on the central Oregon Coast Range.

The productivity and occurrence of spotted owls also depends on the expanding population of barred owls. The range of the barred owl has been expanding from the eastern United States since the early 1900s. Now, the barred owl is found in northern California, the Pacific Northwest, and western Canada. Barred owls have invaded many forests that were previously occupied by spotted owls, and appear to displace resident spotted owls. In some cases, the two species interbreed. The long-term effects of the barred owl invasion will remain unclear for many decades.

Reference:
USGS Status and Trends of the Nation's Biological Resources – Volume 2. Department of the Interior, Washington, D.C. 1998, pp 672-673.

Because spotted owls are a focus of debate about forest management practices, surveying and monitoring these owls will probably remain a high priority on federal and private forest lands. Although most current monitoring involves long-term studies of banded birds, other less costly methods (i.e., transect surveys) of population assessment are needed. Federal, state, and private organizations are involved in monitoring the spotted owl population. Accurate estimates of the population size are difficult to estimate due to their nocturnal nature and limited access to their remote habitat in rugged terrain.

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Status of Amphibian Populations

Type III

Why is this indicator important?

Declining amphibian populations are a concern both in California and globally (Wake 1991). Amphibian populations are declining in many parts of the world, and these declines have been characterized as particularly severe in California (Bradford, 1991). Among the species of greatest concern are the California Red-Legged Frog, which was listed as threatened by the U.S. Fish and Wildlife Service, and the Mountain Yellow-legged Frog *(Rana muscosa*), which is a California Species of Special Concern (Jennings, 1993). Recently, the Department of Fish and Game initiated a monitoring effort to produce baseline data on the status of amphibians in the Sierras and to evaluate how these populations are changing.

What factors influence this indicator?

Amphibians are sensitive to biological, physical, and chemical alterations in habitat. Amphibians absorb chemicals through their skin, making them sensitive to pesticides. There is also evidence that frog populations have declined as a result of the introduction of non-native predator sport fish that will eat small tadpoles (USEPA 1995). They can also be adversely affected by parasites. However, these one-time studies do not document the extent or pinpoint the cause(s) of amphibian population declines. Additional resources are needed to understand the causes of these mortalities, which might reflect significant alterations in forest ecosystems.

References:

Bradford, D.F. 1991. *Mass mortality and extinction in high elevation population of Rana mucscosa*. Journal of Herpetology Vol. 25, Issue 2, pp. 174-177.

Jennings, M.R., and M.P. Hayes, 1993. *Amphibian and Reptile Species of Special Concern in California. Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, under Contract (8023).* 336 pp.

United States Environmental Protection Agency (USEPA). 1995. *Bioindicators of Assessing Ecological Integrity of Prairie Wetlands.* Report # EPA/600/R-96/082. 5.1 Ecological Significance. Washington, D.C.

Wake, D.B. (1991). *Declining amphibian populations*. Science 253 (5022): 860.

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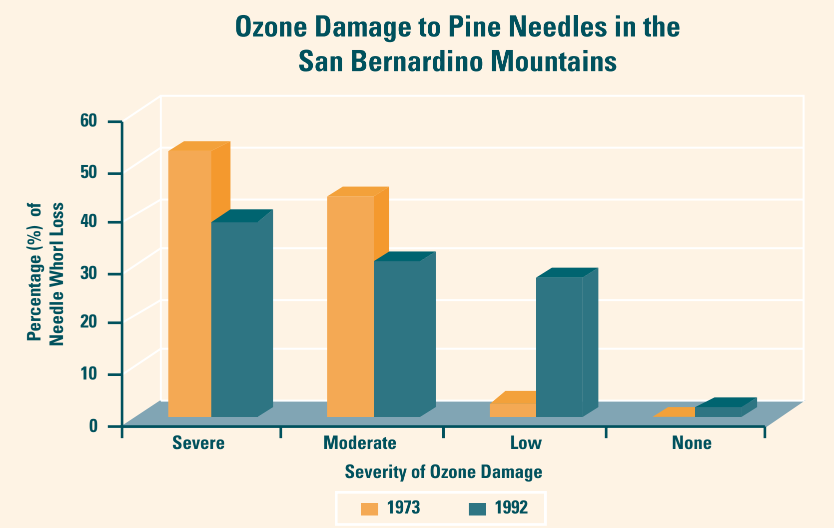
Type III

What is the indicator showing?

Ozone damage causes needle yellowing (chlorotic mottle) and needle whorls to fall off of pine trees prematurely. When ambient ozone levels are high, a higher percentage of whorls are lost. When ozone levels are lower, there is less loss of whorls. The graph shows that as ozone levels in Southern California fell between 1973 and 1992, trees with high and moderate levels of needle loss declined; those with low levels or no loss increased.

Ozone Injury to Pine Needles



Why is this indicator important?

Ozone is the predominant air pollution stressor of plants. It is an air pollutant that is known to damage plant cells and to reduce plant growth. Extensive damage to crops has been reported (McCool et al., 1986) and field studies document the presence of ozone injury on pines throughout California (Arbaugh et al., 1998). Injury to the needles of sensitive pine species, such as ponderosa and Jeffrey pine, has been documented in California since the 1950s (Richards et al., 1968). This information is useful because it clearly links an ambient air pollutant regulated by the state to damage to a valued natural resource, our forests. At present, there is no regular monitoring program to evaluate the effects of ozone on forests.

What factors influence this indicator?

There is strong scientific evidence concerning both the physiological mechanism of ozone-caused plant effects, and that the highest ambient concentrations of ozone in the U.S. occur in California (Miller and McBride, 1999). Over many decades, investigators have developed indicators of ozone injury, such as the severity of needle injury and the number of each year's needles that are retained. In the San Bernardino Mountains, pine injury plots were established in the 1970s that have been periodically resurveyed, most recently in 1997. For this region of the state, ozone air quality has improved in the last 30 years, and injury amounts have been stable or have decreased. Laboratory studies confirmed that the yellowing of pine needles observed in the mountains of southern California was caused by ambient ozone (Miller et al., 1969).

On the other hand, the pine injury plots established in the Sierra Nevada show a different trend. In central California, ambient ozone levels have increased in the past several decades, leading to higher amounts of ozone injury in Sierran forests. The data in the graph are from the San Bernardino study site; no data are shown from the Sierra Nevada research.

Technical Considerations:

Annual injury amounts vary from year to year, but injury amounts accumulate in older age classes of needles. Thus, assessments made at three to five year intervals are usually adequate for quantifying ozone impacts over time. In California, the two most widely used indices of ozone injury to pines are the Forest Pest Management (FPM) index (Pronos et al., 1978) and the Ozone Injury Index (OII) (Miller et al., 1996). The FPM index has been used by the U.S. Departments of Agriculture (Forest Service, USFS) and Interior (National Park Service) to survey tree injury in the Sierra Nevada. The OII has primarily been used by USFS to assess injury levels in the mountains of southern California (e.g., San Gabriel and San Bernardino Mountains), but has also been used in special studies conducted across the state (Arbaugh et al., 1998). Due to the use of one or the other index in most studies conducted in California, Arbaugh and co-workers (1998) developed an algorithm to calculate a FPM value from OII data. This allows comparisons to be made over a range of years and sites in the San Bernardino Mountains and Sierra Nevada.

The Air Resources Board (ARB) collects ambient ozone data at over 100 active monitoring sites across the state (ARB home page at www.arb.ca.gov), mostly in urban areas. The limited data for forest areas have been supplemented through studies using passive samplers (e.g., Arbaugh, 2000), to estimate ozone exposures in forests where monitors are not presently sited. Concurrent assessments of needle injury are made to develop exposure-response relationships, and in some cases, selected sites have been reassessed to investigate long-term trends. To our knowledge, there is no sustained funding for a program to assess needle injury from ozone. As the surveys are labor intensive, the USFS is only able to conduct surveys at irregular intervals. This is projected to continue to be the case unless sustained funding can be obtained. The San Bernardino Plots will be resurveyed at some point; and data from 1997-1998 may be available but are currently not in a form that is ready to present in a manner similar to the graph above. Many sets of measurements have been made in different forests, in different years. To make this data ready for use as a regional or statewide indicator an effort is needed to compile the existing data and to develop a systematic sampling plan.

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Richards, Sr. B.L., O.C. Taylor, and G.F. Edmunds, Jr., 1968. *Ozone needle mottle of pine in southern California*. Journal of the Air Pollution Control Association, 18: 73-77.

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Issue 5: Agroecosystem Health

Agroecosystems are domesticated ecosystems managed for the production of plants or animals. As with natural ecosystems, ecological resources and function are important for their sustainability. However, these ecosystems are substantially altered from their original state and the pressures they experience are often the result of agricultural practices.

Indicators

Conversion of Farmland into Urban and Other Uses (Type I)

Soil Salinity (Type II)

Sub-issues 5.1: Availability of natural resources

Productivity of agriculture is closely linked to two factors:

- The availability of land and its quality. Conversion of agricultural lands to residential, commercial, transportation or other non-agricultural uses increases pressure on the remaining land to produce an equivalent amount. This may increase the use of fertilizer, pesticides, and genetically engineered crops. It may also increase the pressure to convert coastal, forest, grassland and desert ecosystems to human use with attendant impacts on the integrity of those ecosystems and their biodiversity. Further, portions of agricultural land in the Central Valley are becoming unfit for production due to increased salt build-up, often caused by irrigation practices. Similar processes are occurring along the coast.

- The availability of water and its quality. Demand for water use comes from municipal/industrial, and environmental uses in addition to agricultural needs. Historically, agriculture has had an abundance of inexpensive water. In an effort to balance the needs of other users, this easy availability is unlikely to persist. New, more efficient methods of irrigation will be needed in the future. Freshwater quality is also a key resource. Salinity of the soil is linked to the quality of water. Sediments and contaminants leaving agricultural fields can also negatively affect the health of freshwater ecosystems.

Sub-issue 5.2: Positive and negative environmental impacts

Incorrect application or use of pesticides can lead to applicators, field workers, or those who live and work adjacent to areas where pesticides are applied being exposed to unsafe levels of chemicals. These factors, and the persistence of some pesticides in the environment, can lead to levels of chemicals that exceed regulatory standards. Such pesticide build-ups can negatively impact fish and wildlife.

Agriculture can exert positive environmental impacts as well. It can provide habitat for many species. Migratory birds, raptors, and some snakes use agricultural fields during certain times of the year.

There are no indicators for this issue at present.

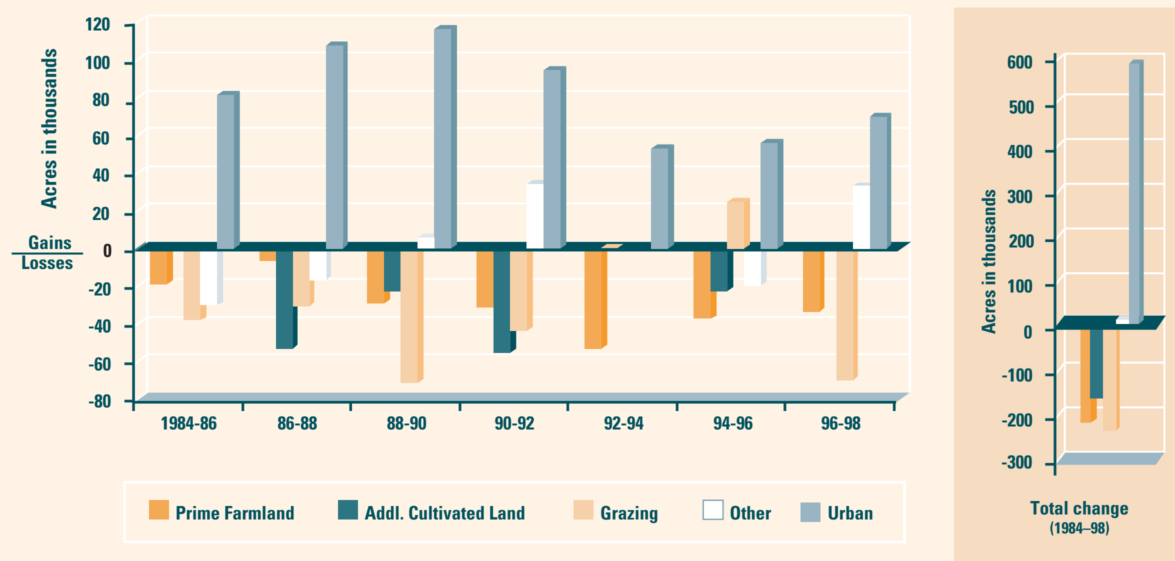
Conversion of Farmland to Urban and Other Uses

Farmland has been lost to urban development, removed from active use, or has been used for environmental restoration purposes.

Type I

Level 4
Goal 6

Gains & Losses in Agricultural and Urban Lands



Why is this indicator important?

Between 1986 and 1998, approximately 5 percent of agricultural lands were removed from productive use. These lands were used for development, ecological restoration, or no longer cultivated for a variety of economic reasons. Between 1984 and 1998, the state's Farmland Mapping and Monitoring Program (FMMP) documented over 500,000 acres of new urban land, an area about the size of Alameda County in the San Francisco Bay Area.

California's rich land, water, and mild climate have allowed it to become the leading agricultural state in the country, and likely in the world (CDFA, 2001). The loss of prime agricultural land has substantial effects on the agricultural industry and the state's economy. Loss of agricultural lands forces farmers to intensify their farming methods to increase crop yields on less land. In some cases, only very large farming interests can afford to make such changes. The urbanization of farmland in mild coastal climates or on high-quality prime agricultural soils shifts farming onto poorer quality land, requiring greater levels of fertilizers to generate the same yields. In addition, conversions between agricultural uses, such as planting vineyards on grazing land, often entails practices such as deep-ripping, which alters the hydrology of the land, eliminating scarce freshwater wetlands and habitat for wildlife.

What is the indicator showing?

Prime farmland and grazing land have been the source of the majority of farmland conversions. "Additional cultivated land" includes non-prime agricultural land. "Other'" refers to low density rural residential, mined lands, and related uses.

Conversion of farmland also incurs human social costs. Because it is less expensive to develop on relatively flat farmland, many new, affordable residential areas are being built in rural areas that used to be far from major urban centers. This, in part, has led to longer and longer commutes; a phenomenon referred to as the "jobs-housing imbalance" (HCD, 2000). These changes have had significant effects on the social fabric of cities and the new suburbs as well as the economic and ecological health of rural areas.

What factors influence this indicator?

Population growth in California is the primary factor driving the conversion of agricultural land to residential use. However, the rate of conversion can be slowed by employing sound land use principles. By understanding the patterns of existing land use, the needs of the underlying ecosystems, and the demand for housing, planners and local governments can minimize the loss of agricultural land. Sound land use planning can avoid fragmenting agricultural and natural ecosystems into small, units that cannot function properly.

Technical Considerations:

Data Characteristics

Loss of farmland has been calculated in different ways, depending on how terms are defined, the level of detail, and the methodology used in studies. Some sources are solely statistical, being derived from landowner surveys (U.S. Census of Agriculture) or sample point assessment (U.S. Department of Agriculture (USDA) - Natural Resources Inventory). Others create continuous geographic coverages that are more useful for specific planning functions.

The Department of Conservation's Farmland Mapping and Monitoring Program (FMMP) updates its land use inventory every two years, based on photo interpretation and other sources, to report on agricultural conversion. The FMMP maps 90 percent of non-government land in California. The FMMP study area is 44.6 million acres as of 2000. It has increased from 30.3 million acres in the initial project year, 1984, as more soil surveys were completed by the USDA. Urban land is defined by FMMP as having a density of one building or more per 1.5 acres. Agricultural land is differentiated by irrigation status and soil quality, hence it includes both land use and land capability components.

Other programs that conduct land use mapping on a regular or occasional basis include the Forest and Rangeland Assessment Program (FRAP) of the Department of Forestry and Fire Protection, and the Land Use Section of the Department of Water Resources (DWR). FRAP estimates urbanization and sources of converted land. They categorize land as "urban" when there is one building per 20 acres in order to account for the impacts of roads and other

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American Farmland Trust (AFT), 1986. *Eroding Choices, Emerging Issues*. www.farmland.org

California Department of Food and Agriculture (CDFA), 2001. *California Agricultural Resource Directory 2000*. www.cdfa.ca.gov/card

California Department of Conservation, Farmland Mapping and Monitoring Program (FMMP), 2000. *California Farmland Conversion Report, 1996-98*. www.consrv.ca.gov/dlrp/fmmp.

California Department of Housing and Community Development (HCD), year 2000 Chaptered Bills, AB 2054 (Torlakson) housing.hcd.ca.gov/leg/2000Chaptered Bills.html
Housing Elements, Land Use and Planning

Kuminoff, N.V., A.D. Sokolow, and D.A. Sumner. 2001. *Farmland conversion: perceptions and realities*. Agricultural Issues Center, University of California. aic.ucdavis.edu/pub/briefs/brief16.pdf

infrastructure and household pets on natural communities. Satellite image classification is combined with data from other sources to determine change. Like FMMP, DWR relies on aerial photo interpretation, with a greater level of detail but lower frequency of mapping (6-8 year update cycle).

Strengths and Limitations of the Data

Gaps in statewide coverage, regional variations, and definitional differences among existing data sources will need to be addressed to determine specifically what should be measured as an indicator on the status of agricultural ecosystem health. Additional analysis will be provided in future EPIC reports.

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Soil Salinity

Type II

Why is this indicator important?

Approximately 30 percent of California's agricultural lands have a salinity problem (Tanji, 2001). The major problem occurs in the San Joaquin Valley, with secondary problems in the Imperial and Sacramento valleys. The quality of the soil plays an important role in the health and sustainability of California agriculture. Soil salinity refers to the amount of salts mixed in the soil. Saline soils impairs the growth of most crop plants. In California, 4.5 million acres of irrigated cropland, primarily on the west side of the San Joaquin Valley, are affected by saline soils or saline irrigation water. At present, data exist on soil salinity; however, additional work is needed before the data can be presented in a quantitative form.

What factors influence this indicator?

Soils from the San Joaquin Valley and other regions become saline because the water used for irrigation contains high amounts of dissolved salts. Since plants take up water, but not salts, the salts remain behind, increasing the salinity of the soil. Additional sources of salts include animal manure, biosolids, and gypsum – all routinely used in agriculture. Compounding the matter is the reuse of irrigation drainage water. In an effort to conserve water, some farmers collect drainage water after it has been used to irrigate crops. Drainage water contains higher amounts of salts than river water.

To improve the quality of the San Joaquin, Imperial, and Sacramento Valleys' soil for crops, water must be used to literally wash away the salts. This leachate water then must then be drained to evaporation ponds, or to the ocean, rather than reapplied to cropland.

Technical Considerations

Data on soil salinity is compiled by the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, 1992). This information will be reviewed and compiled by EPIC staff for future reports.

References:

Tanji, K. K. 2001. *Are salinity and trace elements a problem in irrigated California land?* California Agriculture (submitted).

National Resources Conservation Service, U.S. Department of Agriculture, 1992. *Salinity levels in the United States*. www.nrcs.usda.gov.

Additional information can be found at the Kearney Foundation Web site: www.cnr.berkeley.edu/~gsposito/Kearney.

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Indicator

Urban tree canopy (Type III)

Issue 5: Urban Ecosystems

Urban ecosystems have been almost completely transformed for human purposes, thus the pressures and concomitant effects on the urban environment are primarily judged in terms of their human impacts. Air quality, water quality, and the management of discarded material are a few of the issues important in urban ecosystems. These issues are covered in other sections of this report.

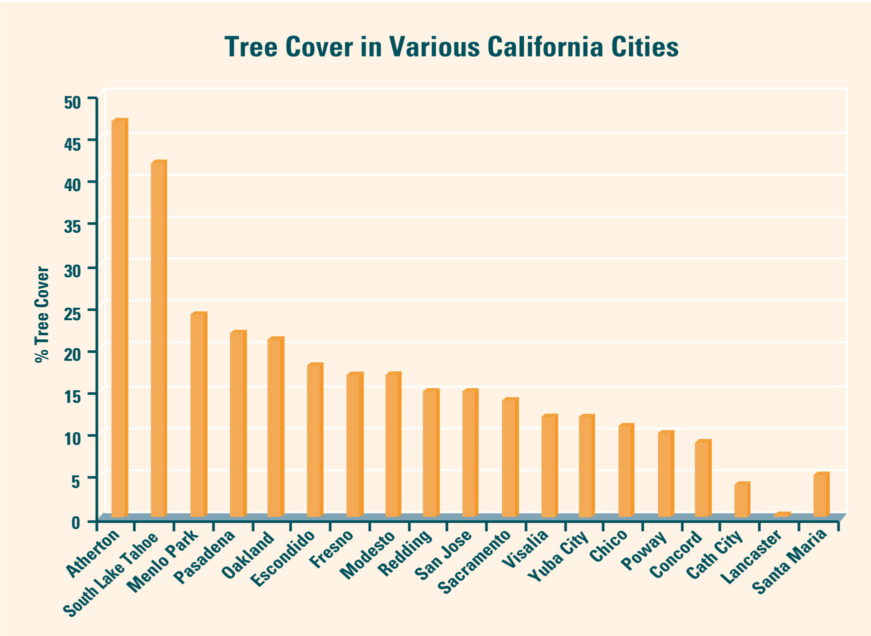
Sustainability issues are the focus of this section. The balance sought in urban ecosystems is one that provides a pleasant environment for humans, maintains some integrity of the natural landscape for wildlife, and minimizes the use and disposal of natural resources. Today, in particular, the size of the "energy-use footprint" is especially important in California. A variety of sustainability and quality of life issues have been identified by those working on the EPIC project and are put forth at this time to indicate our intention in the future to address these concerns:

- Recreation availability and environmental impacts
- Employment opportunities in communities that have traditionally extracted natural resources
- Impacts of technology, such as genetic research, on productivity and ecological health
- Quality of living space and lifestyle
- Civic engagement in conservancies, restoration, and re-vegetation
- Regional planning and resource management related to natural resource protection
- Population growth and settlement patterns, including urban sprawl

Developing a group of urban ecosystem indicators to address these complex issues is beyond the scope of this first EPIC report. In the future, however, indicators will be developed to examine the issues identified above. For this report, one integrative indicator was selected, urban tree canopy. There is particular interest in this indicator at this time because tree canopy not only provides a pleasant environment for people and habitat for urban wildlife, but it can also reduce energy consumption by providing shade for homes and apartments and minimizing temperature increases associated with concrete roads and sidewalks.

Urban Tree Canopy

Type III



What is the indicator showing?

Tree cover in a selected group of California cities ranges from less than 1 percent (Lancaster, in the desert) to over 45 percent (Atherton, in the San Francisco Bay Area).

Why is this indicator important?

Urban ecosystems are where the majority of California's population lives and works. While the quality of urban ecosystems is based on a suite of parameters such as water quality, air quality, energy use, and traffic congestion, aesthetic factors are also important to urban quality. For example, several authors have identified the extent and variation of tree cover in urban areas of California as a measure of the importance placed on natural amenities. Urban tree cover provides insight into local land use and urban aesthetics, and serves as a basis for adapting future land use plans to optimize the beneficial aspects of tree cover. In addition, urban tree cover has been associated with a number of unquantified benefits, including removal of ambient air pollutants, removal of greenhouse gases, and reduction in energy/electricity use (Huang, et al., 1990; Nowak, 1994; Rowntree and Nowak, 1991).

What factors influence this indicator?

Urban tree cover in the U.S. ranges from 0.4 percent in Lancaster, California, to 55 percent in Baton Rouge, Louisiana (Nowak et al., 1996). In this study, surrounding natural environment and land use were the two main factors governing the extent of tree cover in urban areas. Cities established on forest land typically had greater tree cover than those on desert land (e.g., Lancaster). Moreover, land use plans that included areas set aside for greenspaces or parks had more tree cover than those that did not expressly incorporate space for vegetation. At present, the establishment and maintenance of urban forests is of concern to decision-makers who recognize the benefits they provide. These benefits include reduced energy use, habitat for birds, and pleasant aesthetics, to name a few. The benefits of tree cover in desert cities is a question that has important economic and natural resource implications. As urban development is projected to increase in the state, urban tree canopy is an important element that must be considered as part of regional planning.

Technical Considerations:

Various measures are used to describe urban tree cover (e.g., percent tree cover, total greenspace, canopy greenspace)(Nowak et al., 1996). Data of this kind are collected in large metropolitan areas by the USDA Forest Service; less labor-intensive measures of tree cover such as the presence/absence of tree planting ordinances, budget allocations for tree maintenance, or numbers of tree planting programs may be more available for medium-to-small urban areas.

Nowak et al. (1996) list four methods for estimating urban tree cover from aerial photographs — crown cover scale, transect method, dot method, and scanning method. Assuming that the required services and meta-data for interpretation of aerial photographs can be enlisted and obtained, estimating tree cover by any of the above four methods would provide reliable information. Standard statistical analysis could then be applied to distinguish differences among cities of different sizes, land-use types, etc.

The manuscript by Nowak et al. (1996) lists tree cover indices from 16-cities in California, primarily from unpublished data from the USDA Forest Service. It is not known how many other unpublished data sets are available or what data can be obtained from other published reports to establish trends for urban tree cover.

References:

Huang Y.J., H. Akbari, and H. Taha, 1990. *The wind-shielding and shading effects of trees on residential heating and cooling requirements*. ASHRAE Trans., 96: 1403-1411 (Original not seen)

Nowak D.J., 1994. *Air pollution removal by Chicago's urban forest*. In: EG McPherson, DJ Nowak, and RA Rowntree (Eds). Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service, General Technical Report NE-186, p. 63-81.

Nowak D.J., R.A. Rowntree, E.G. McPherson, S.M. Sisinni, E.R. Kerkmann, and J.C. Stevens, 1996. *Measuring and analyzing urban tree cover*. Landscape and Urban Planning, 36: 49-57.

Rowntree R.A. and D.J. Nowak, 1991. *Quantifying the role of urban forests in removing atmospheric carbon dioxide*. Journal of Arboriculture, 17: 269-275. (Original not seen)

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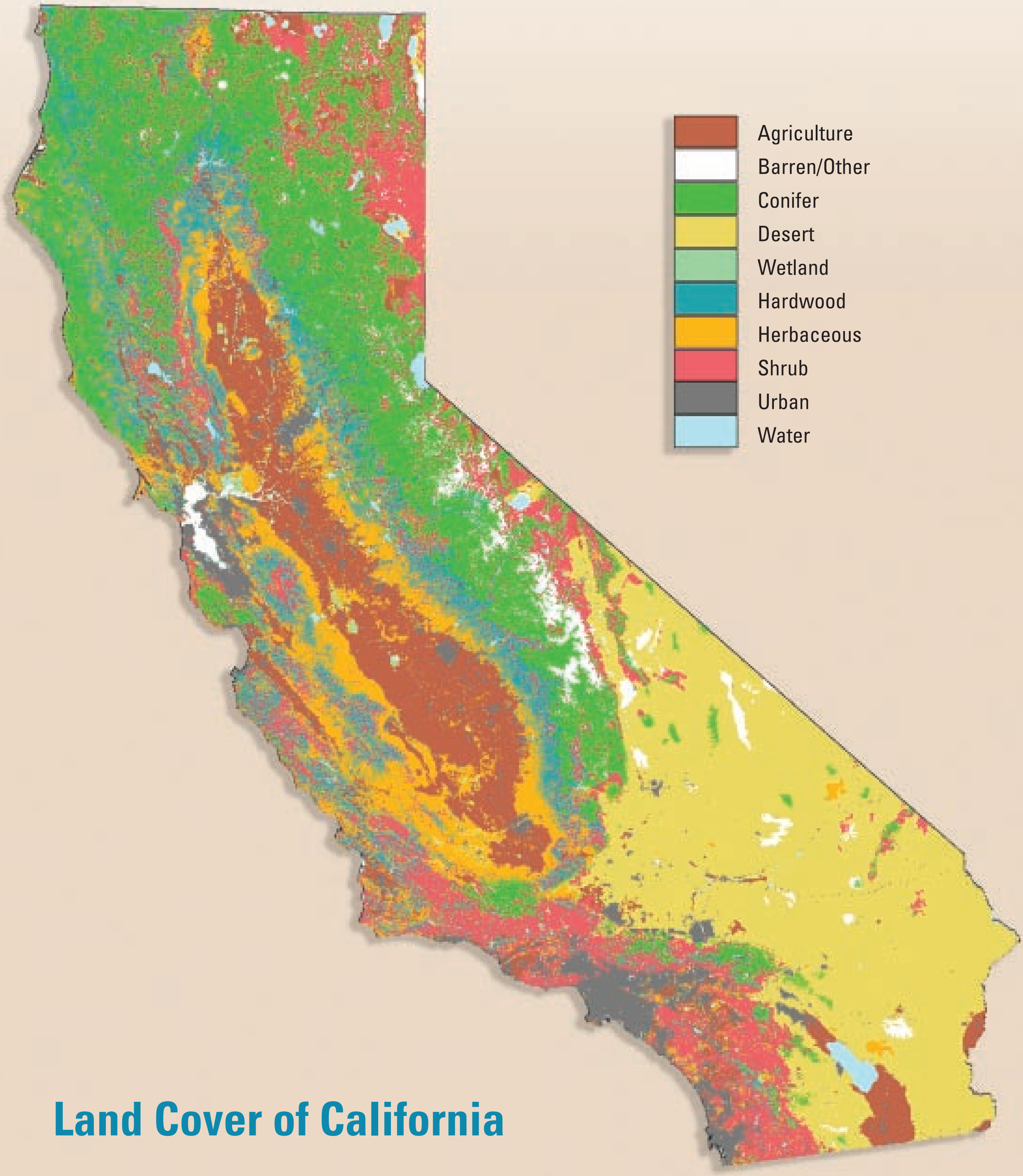
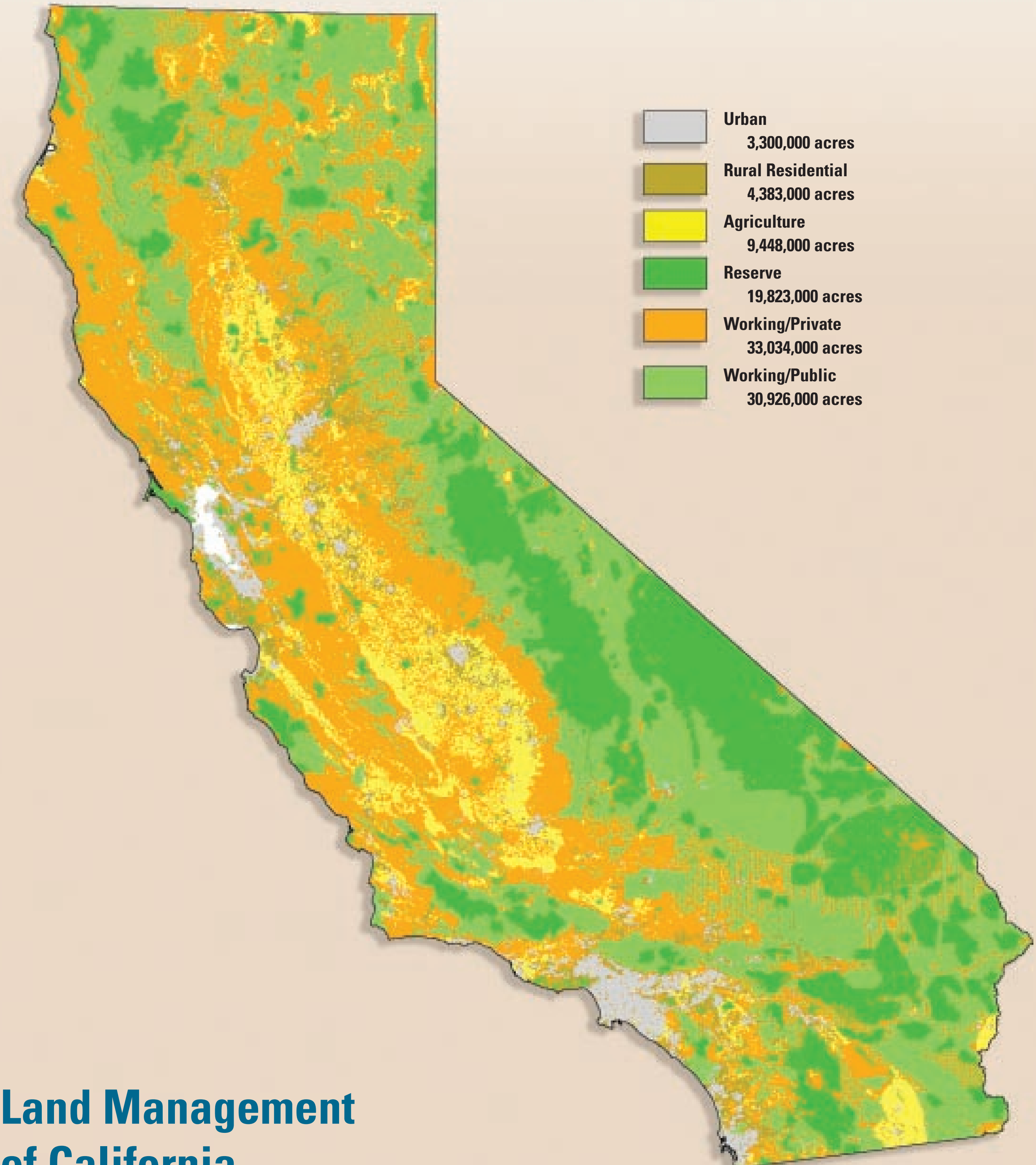


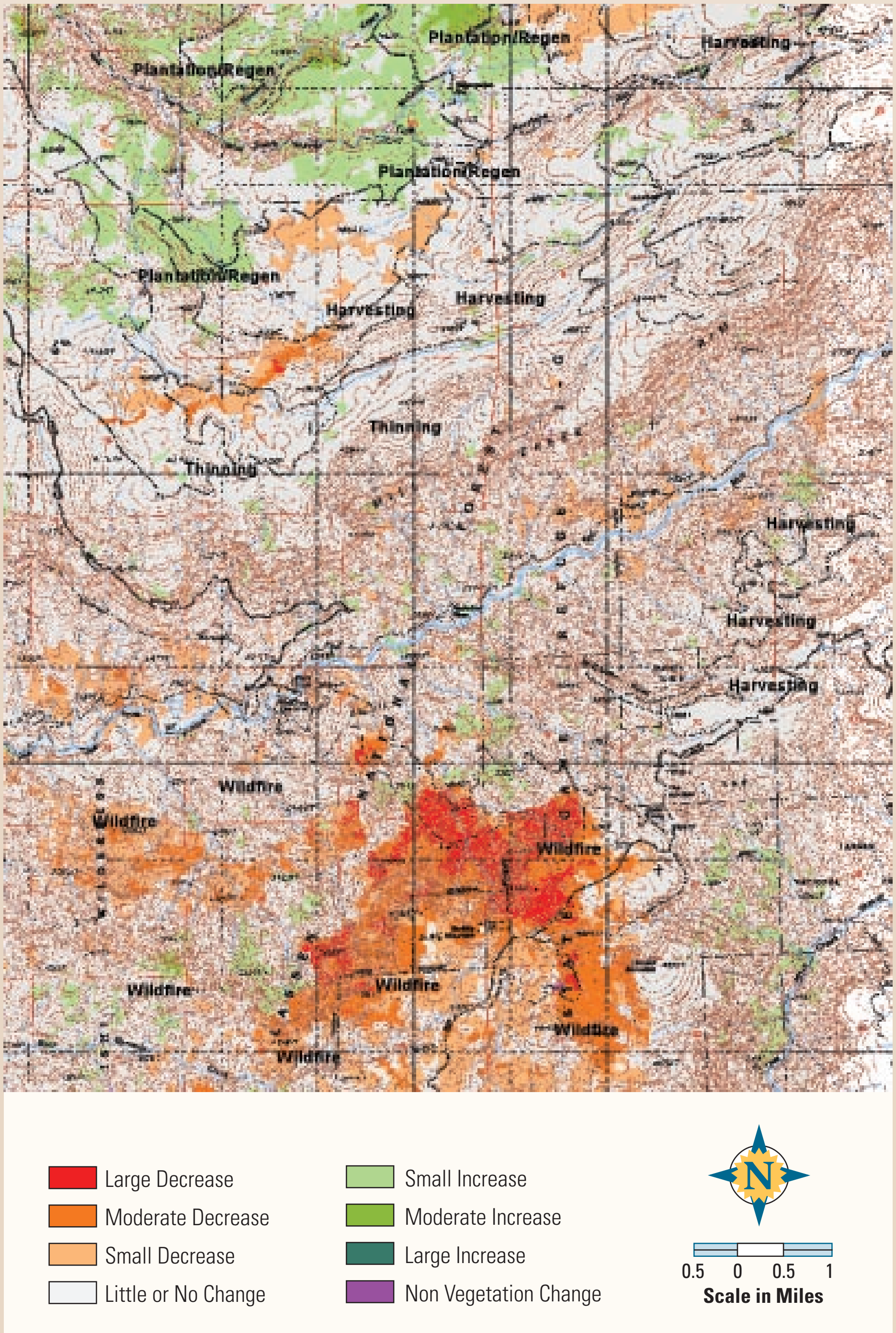
Land Cover of California



Land Management of California

Change in Forest Canopy Map

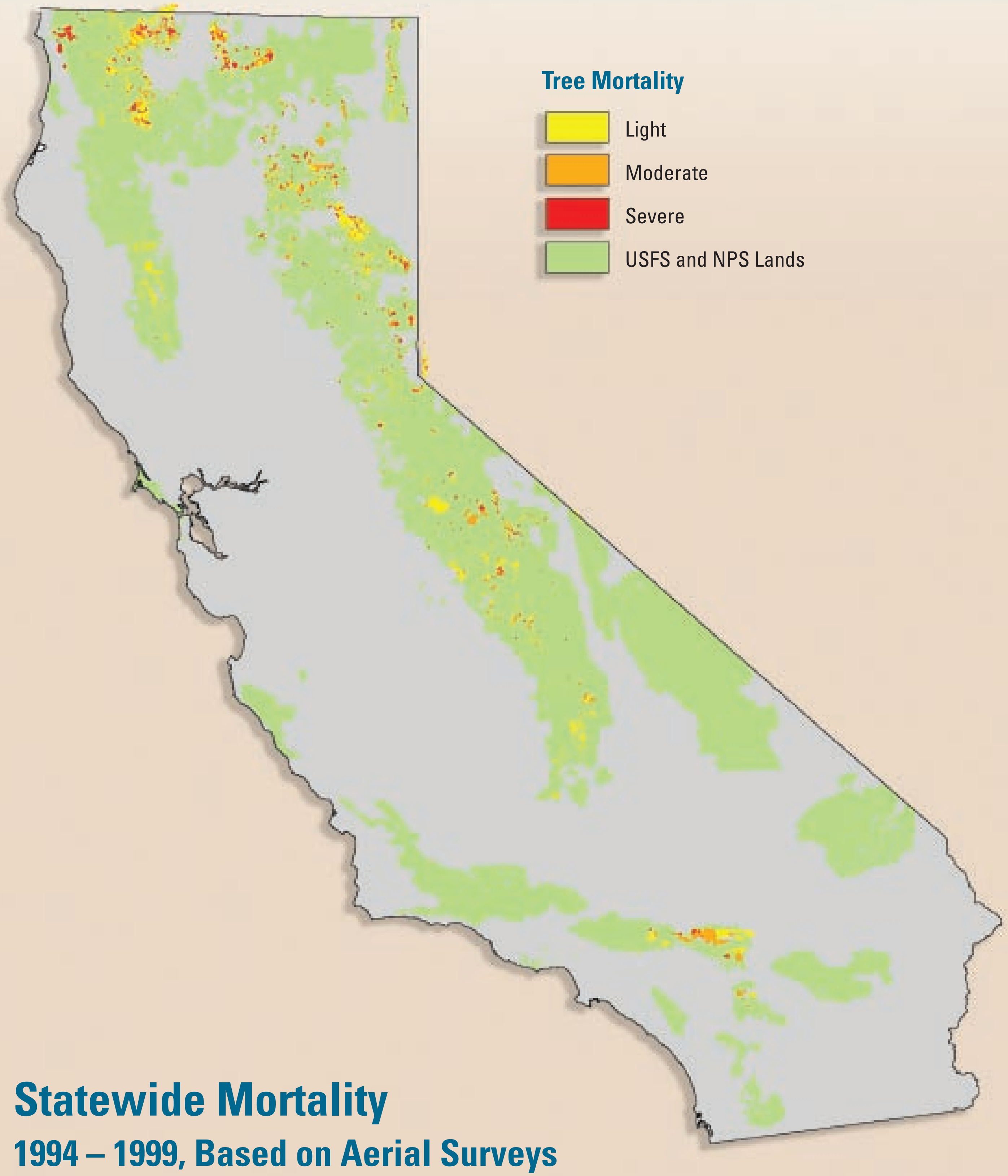
Portion of change map with verified cause in the Barkley Mountain quadrangle, Lassen National Forest, California



Forests are always in a dynamic state of change as younger trees grow to occupy gaps within forests. As forests grow, trees are lost due to mortality, fire, harvest, and development. Identifying the spatial patterns of these changes requires analysis of the change of canopy cover between two time periods.

The figure below illustrates a detailed map of changes developed from a comparison of two satellite images taken 5 years apart as part of a statewide assessment of changes in vegetation. This analysis accurately captures the area and causes of changes in total vegetative canopy cover, but not the changes in total biomass.

For the combined region encompassing the Sierra Nevada and the Modoc Plateau to the north, more than 90 percent of all forest areas showed no change in forest canopy between 1990 and 1996. Approximately five percent of the area showed an increase in canopy cover while another four percent showed a decrease.

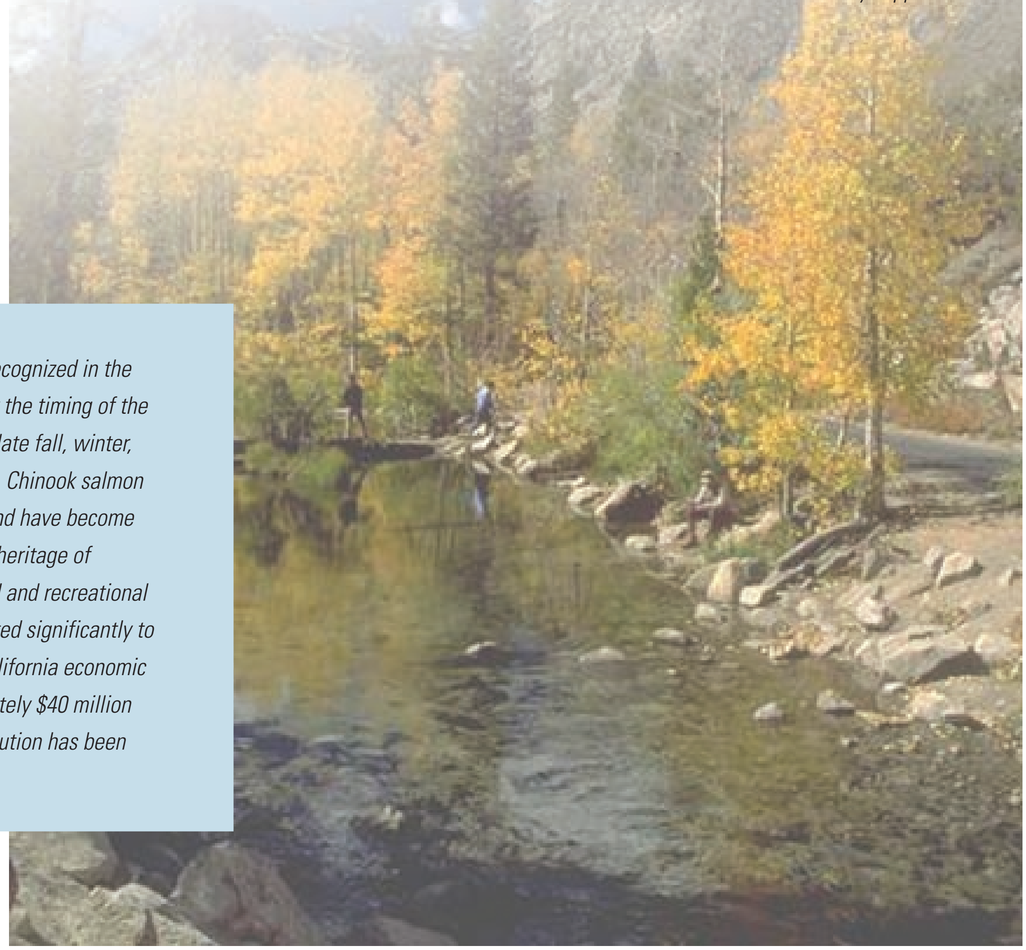


Statewide Mortality

1994 – 1999, Based on Aerial Surveys

Aquatic Ecosystems

The health of California's aquatic ecosystems has been significantly degraded over the past 150 years due to major land and water development activities. The decline in California's chinook salmon populations is an indicator of the degraded health of the aquatic environment. However, public sentiment for restoring the state's lakes, rivers, and streams has never been stronger. Significant progress has been made, and will continue to be made, to protect and restore our aquatic ecosystems and the fish and wildlife communities they support.



Four chinook salmon runs are recognized in the Central Valley, differentiated by the timing of the adult spawning migration (fall, late fall, winter, and spring-run chinook salmon). Chinook salmon have been historically valued and have become part of the cultural and natural heritage of northern California. Commercial and recreational fishing for salmon has contributed significantly to the economy. The estimated California economic impact for 2000 was approximately $40 million dollars. Historically, this contribution has been much greater.

Desert Ecosystems

The U.S. government treats the desert tortoise as an indicator to measure the health and well being of the desert ecosystem.

Mona Bourell, California Academy of Sciences

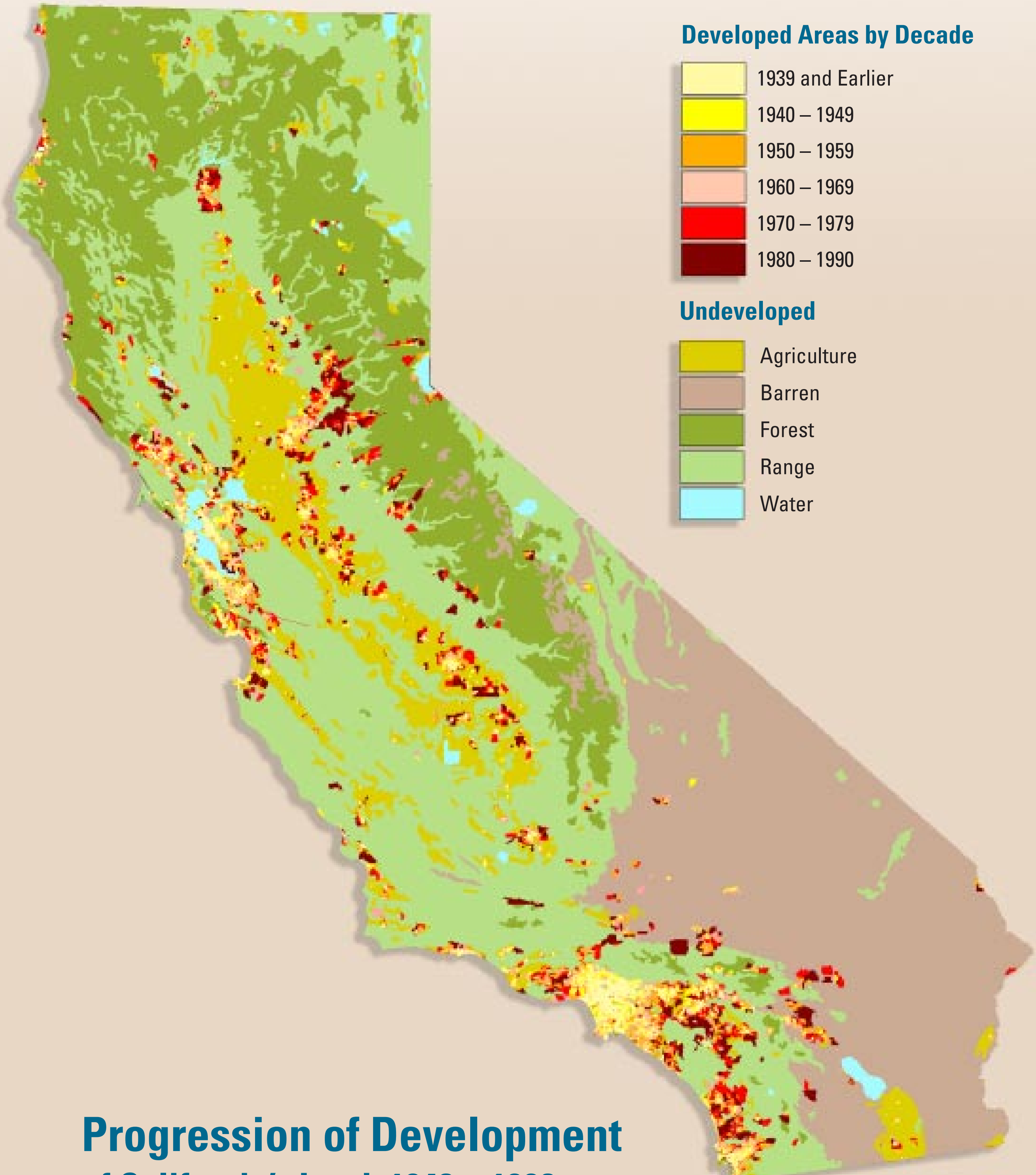
The desert tortoise population has declined dramatically because of human and disease-induced mortality, as well as destruction, degradation, and fragmentation of habitat. There are no stable or increasing populations in "critical habitats" in California, the 4.75 million acres of land designated by the U.S. Fish and Wildlife Service as critical for the recovery of the tortoise. The 2002 census recently completed in established study plots showed a continued downward population trend.

Forest, Shrub Land and Grassland Ecosystems


J & K Hollingsworth, USFWS

In 1990, the federal government placed the northern spotted owl on the list of threatened species. The northern spotted owl inhabits the forests of the Pacific Coast region from southwestern British Columbia to central California and has an apparent preference for large tracts of old growth forest.

California's forests, shrub lands and grasslands cover over 56 million acres. These lands have diverse wildlife habitats and tremendous biodiversity. Many of these lands are in a period of recovery in terms of ecological integrity after decades of use. Conversion to other land uses such as residential and commercial development are slightly decreasing the total area, especially near major metropolitan areas. Conserving the health of these ecosystems by protecting vital habitats, managing for appropriate levels of use, and restoring ecosystem functions while enabling economic growth will remain a challenge for California in the future.



Progression of Development
of California’s Land, 1940 – 1990

CHAPTER 4

Findings and Future Directions

Introduction

Over the years, California has devoted substantial efforts toward environmental protection and resource management. While the state has been, in many instances, a national and international leader in developing and implementing solutions to its environmental problems, there are very few mechanisms to quantify and track the impacts of these solutions on the environment. As environmental issues and alternatives to solving them become more difficult and complex, it is increasingly critical to have the capability to recognize problems early, and to devise strategies based on a consideration of the full range of possible environmental consequences.

Environmental indicators can provide an objective, scientifically-based representation of the condition of the environment. They can be used in communicating information to the public. They can help improve the understanding of the state of the environment, how its different components might interact, and how it might be affected by human activities. Because of this, environmental indicators are powerful tools in "results-based management systems," in which information about the environment is considered in strategic planning, priority setting, resource allocation and other decision-making processes.

The Environmental Protection Indicators for California (EPIC) Project has produced this report after an intensive year's effort to build a framework for an environmental indicator system for California. This framework lays out the process and criteria for indicator development, and presents an initial set of indicators.

Developing the Indicator Selection Process

This first task in constructing the EPIC framework was to establish a process that will guide the identification, selection and development of the environmental indicators to be included in the system. This process is described in Chapter 2. It requires the application of criteria designed to ensure that the indicators are scientifically valid, meaningful, and useful in decision-making; the process also classifies indicators based on the availability of data. Some flexibility was incorporated into the process to allow the use of certain data sets that do not strictly meet the criteria in the absence of other data, provided that a reasonable approximation of the parameter of interest can be presented.

The scope of the initial effort covered issues that relate to the mission of Cal/EPA and its constituent entities, and to areas of overlapping jurisdictions with the Resources Agency and the Department of Health Services. Indicators relevant to the central missions and mandates of the latter two entities are the responsibility of those agencies, and will be addressed by their strategic planning functions. Indicators for more complex areas such as environmental justice, sustainability and pollution prevention will be addressed in subsequent years. Clearly, these areas include some high priority issues for California;however, developing indicators that are in line with the state's goals in these areas will require more time. Different types of environmental data will need to be integrated with non-environmental information on such factors as social, economic, demographic, and others. In addition, the environmental indicators may need to be refined to a desired level of detail (such as at a community level).

The indicators in this report were developed through a close collaborative process involving staff in Cal/EPA, the Resources Agency and the Department of Health Services, with input from an external stakeholder group, an interagency advisory group of policy-level state agency representatives, and participants at a two-day conference. The collaborations offered excellent opportunities to build or strengthen partnerships among the participants and the organizations they represent. The project brought together Cal/EPA and the Resources Agency, the two cabinet-level agencies responsible for protecting and managing California's environmental resources.

Encouraged by the successful use of environmental indicator systems (notably those in New Jersey, Florida, New Zealand and the Netherlands) to guide decision-making, Cal/EPA has committed to moving toward a results-based management system. While this new direction has been generally well received, it will take time before it is fully implemented. It will require integrating indicators into goals, milestones and strategies, then using the indicators to track progress. Using indicators will necessitate a good understanding of the significance of the trends shown by the indicators, and of the factors that influence them. For example, an indicator showing little or no change in its trend may suggest that efforts are no longer needed to address the problem; on the other hand, it is more likely to suggest that the efforts to address the problem have been effective in keeping it under control, and discontinuing these efforts would be detrimental to the environment. Further, such a trend may actually represent tremendous strides in addressing a problem, particularly when driving forces, such as population growth, are taken into account. Cal/EPA has adopted eight overarching strategic goals (listed in Chapter 1), progress toward six of which can be tracked with the use of environmental indicators.

Indicator development began with a concerted effort to identify the significant environmental issues of concern confronting California – issues that need to be better understood by quantitatively characterizing them using indicators. The issues were then organized in a manner that facilitated the identification of possible indicators and the data with which they can be developed. For this report, the organization parallels the areas of responsibilities of Cal/EPA's environmental programs. This organization may have limited the definition of issues and identification of possible indicators to areas covered by existing mandates, activities, and regulatory provisions of Cal/EPA. For example, the selection of Type III indicators (i.e., indicators requiring data) may have been biased toward data that can be collected by simply expanding existing efforts, or data based on preliminary or one-time efforts undertaken by a regulatory program.

This report takes an important first step in presenting, in a single document, a collection of environmental indicators derived from various sources, and spanning a wide range of significant environmental issues confronting California. By examining the indicators individually and collectively, environmental programs can gain a better awareness of what is known about the condition of the state's environment, what information is required to understand certain issues, what the potential problem areas might be, and possible ways of addressing them and measuring success.

Selecting the Indicators

Significant challenges were encountered during the process of developing the initial set of indicators. Indicators must meet all of the following primary criteria (discussed in Chapter 2):

- **Data quality** (the indicator is based on scientifically valid data collection)
- **Representativeness** (the indicator reflects the environmental issue for which it was selected)
- **Sensitivity** (the indicator can detect meaningful differences in environmental conditions)
- **Decision support** (the indicator supplies information that can support decision-making)

The initial set of environmental indicators relies heavily upon established environmental monitoring and data collection activities in California. Although there is extensive data collection in the state, the available data are of variable quality for indicator development. Environmental data collection has generally been reactive, often carried out to characterize known or suspected problems, or to formulate and test the effectiveness of regulatory strategies. In many cases, data were not collected with the intention of surveying conditions to establish status and trends. This results in data that reflect conditions at a contaminated site or a polluted area (often called a “hot spot”), rather than providing an assessment of environmental conditions at a region or of the state as a whole. Most frequently, when the site is cleaned up, or the pollution abated, data collection ceases. This manner of data collection generally does not support indicator development. To meet the data quality criterion for indicator selection, the data must be representative of the issue or system, and must be based on systematic, ongoing environmental monitoring, such as that conducted under the decades-long statewide monitoring for criteria air pollutants.

Identifying representative indicators using existing data was also a challenge. A significant portion of current data collection focus on tracking activities such as permits issued, grants awarded, or violations committed. This type of data generally do not support environmental indicators because they convey little about the condition of, or effects on the environment. In other cases, it was difficult to identify which indicator would best represent the issue. For example, selection of sentinel or indicator species to represent the condition of a particular ecosystem requires significant knowledge of the system of interest. Expertise was not always available, and time constraints precluded consulting outside experts for input on all issues.

This initial report primarily presents indicators of statewide trends. While statewide indicators may provide a good overall summary, they generally do not represent regional conditions. California’s environment is very diverse, and includes many unique regions and ecosystems (such as Lake Tahoe, Death Valley, the San Francisco Bay Delta System, and the California/Baja California, Mexico border region) that cannot be adequately characterized by statewide indicators. Indicators specific to air basins, watersheds and ecological regions can better reflect environmental change, and provide more relevant information to support decision-making. Examples of regional indicators are air basin-specific trends in emissions or ambient levels of criteria air pollutants (see Air Quality section in Chapter 3).

The sensitivity of the measures used for indicators was the third primary criteria. The sensitivity of the data used in this first set of indicators spans a wide range. Some data possess a high degree of sensitivity. Other data were affected by confounding variables and had relatively poor sensitivity. For example, economic activity influenced many of the measures used; therefore, the observed trends may be as much a reflection of changes in the economy as they are a reflection of real changes in the environment. Explanations of how these confounders affect the trends in the indicator were included in the narratives for the indicator whenever possible. In many cases, however, the influences of these variables are not well understood.

The ability of the indicators to advise decision-making is dependent on the degree to which they meet the previous three criteria. If concordance is weak, the indicators could provide misleading information. As the quality, sensitivity, and representativeness of data and the indicators derived from them improve over time, the indicators will become more useful in decision-making. Further, the ability of environmental programs to use the indicators as considerations in decision-making depends upon how well the factors that affect the environmental conditions are understood. This will require enough of an understanding of the system in question to determine how human activity (governmental actions, actions by the regulated community, or societal actions) can effect changes in pressures upon the environment, how these changes can in turn affect ambient environmental conditions, and finally, how environmental conditions can impact human or ecological health.

The EPIC process also specifies secondary criteria that, although not essential, made an indicator more desirable. These criteria address whether an indicator can be used to anticipate changes, can be compared to indicators in other programs or systems, is cost-effective, and is based on, or can be compared to, a benchmark or reference value. These criteria were applied to indicator selection to the extent it was possible to do so.

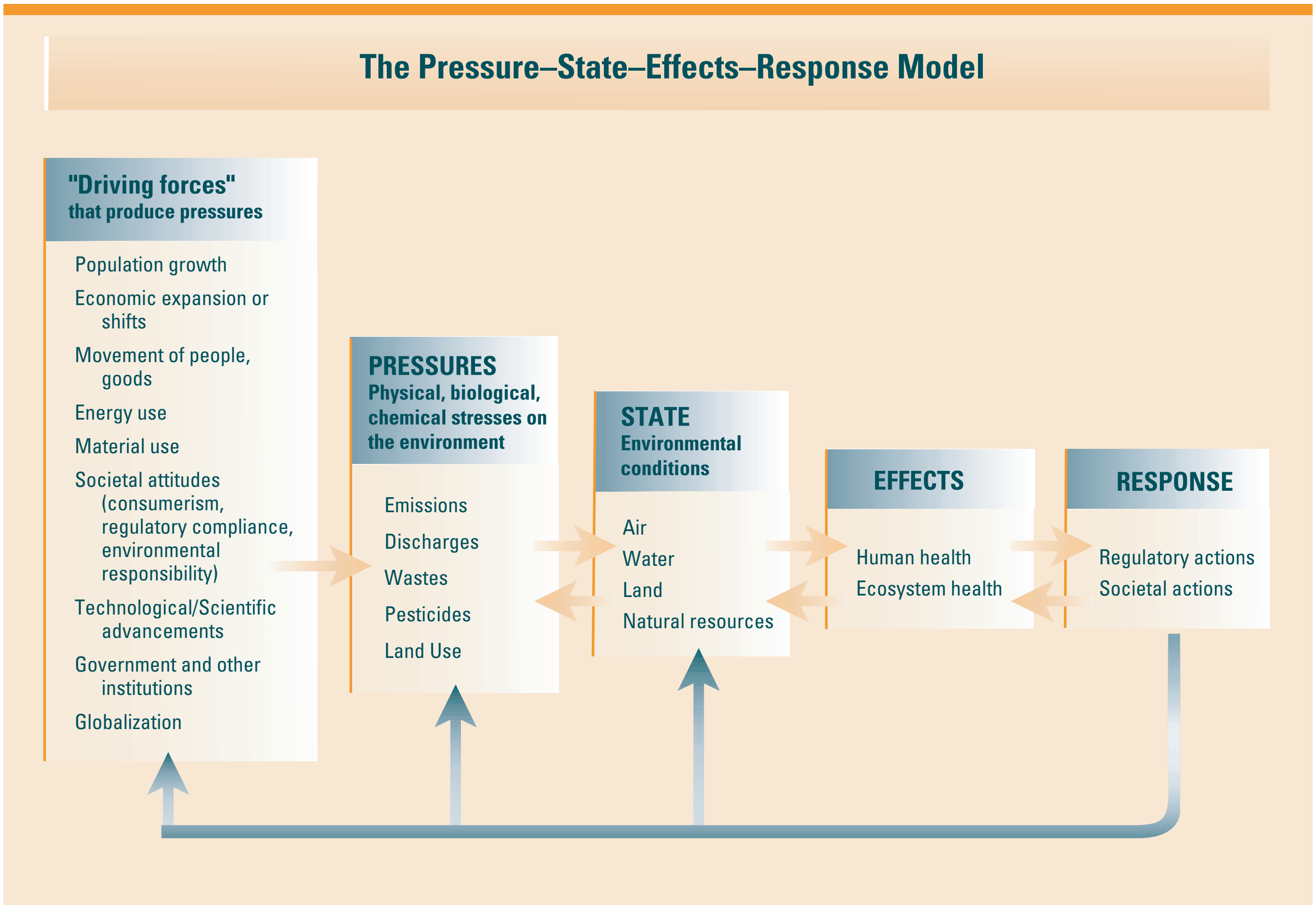
The Indicators

Valuable insight can be gained by viewing the indicators with reference to the "pressure-state-effects-response" conceptual model (see diagram on the following page), extended to include the driving forces that can produce pressures upon the environment. Population growth is a driving force that can create significant pressures upon the state's environment and natural resources. Already the most populated state in the country, California continues to grow faster than the rest of the nation, having added over half a million people to its population every year for the past four years. California is currently home to an estimated 35 million people, with more than three-quarters of the population living in 12 of the state's 58 counties. Population growth impacts the other major forces that drive change, such as the economy, the consumption of energy and materials, and the movement of people and goods. All of these forces can influence one another, as well. For example, increased economic activity creates jobs that draw more people into the state. The increased production of goods increases energy and material consumption and the need to transport goods. Changes in the nature of the California economy, such as the growth of service-oriented businesses and the information technology industry, can produce a different set of pressures. Recognizing the trends in the driving forces that create the physical, chemical and biological pressures on California's natural resources provides a context for better understanding the trends revealed by the environmental indicators. Many of the background indicators presented in this report portray a partial picture of the trends in the "driving forces."

Despite the increasing strain produced by the driving forces on California's environment, certain environmental indicators show trends that are consistent with the state's goals of improving, restoring or preserving the environment. For example, emissions and ambient levels of criteria air pollutants generally show declining trends. Contaminants in drinking water are rarely found at levels exceeding regulatory standards. Increasingly, a greater percentage of all solid waste is being diverted from landfills, and less hazardous waste is produced per unit of economic activity. These successes can in part be attributed to California's environmental programs.

Other indicators show a lack of improvement or a worsening of environmental conditions. The population of winter run chinook salmon in the Central Valley has declined to extremely low levels. The clarity of Lake Tahoe, an indicator of overall lake function, continues to decline. The population of the desert tortoise, a federally designated endangered species, has declined significantly since 1980. In some air basins, levels of inhalable particulate matter (PM10) have not been significantly reduced over the last ten years.

Finally, additional challenges stem from a lack of data with which to gauge the status of certain environmental issues. For example, status and trend data are lacking on such issues as indoor air quality, the impacts of pesticide use on air and water quality, the impacts of environmental exposures on human health, and many aspects of the state's natural resources. When viewed against the "pressure-state-effects-response" conceptual model, most of the indicators presented in this report fall into the "pressures" or "state" categories. Indicators of "effects" on human and ecological health are few and, over time, more indicators in this category should be included. However, human health is influenced by the interaction among exposures to environmental contaminants, genetics, and lifestyle factors such as smoking, diet, and exercise. Until adequate scientific information is available to define and quantify how these factors contribute to disease, indicators of environmentally-related health effects will be difficult to develop. In the meantime, a better understanding of human exposures to harmful environmental contaminants may be gained from tracking data on the levels of environmental contaminants in the human body.



Issue Area-Specific Findings

From the initial set of indicators, some key findings in several areas have become apparent. What follows are summaries of these key findings and future directions for each major issue category in this report.

Air Quality

Through diligent monitoring efforts, the California Air Resources Board has consistently collected air quality data that are ideally suited for developing indicators. The extensive monitoring by the state originally arose out of the need to tackle some of the worst urban air pollution in the country. The significant areas of poor air quality are regional in scope, and located in the major urban air basins of the state (South Coast, San Joaquin Valley, Sacramento Valley, San Francisco Bay Area, and San Diego Air Basins). Thus, a regional approach was taken to monitor air quality as methods were implemented to reduce air pollution. Reducing air pollution, particularly in urbanized regions, is a continual challenge as the population of the state increases (see Population Demographics and Transportation background indicators).

Major efforts have been made in reducing air pollutants over the last 20 to 30 years. The largest benefits have resulted from reductions in emissions from gasoline-fueled vehicles, one of the main sources of air pollution in urban air basins. The major findings of the air indicators include:

- Carbon monoxide has ceased being a major air pollutant in all areas of the state, except in some border areas with Mexico and in the South Coast Air Basin, which have had infrequent exceedances of the standard.

- While ozone levels still intermittently exceed the state standards in California's five major air basins, total yearly exposure to ozone has been reduced by over 75 percent in the most polluted regions over the last 10 to 15 years.

- Levels of particulate matter (PM10) have been only modestly reduced (by about 20 to 40 percent) in some major air basins, and not significantly reduced in a few others. Urban sources of PM10 currently represent one of the biggest challenges in reducing air pollution.

Efforts initiated on the following air quality issues will support the development of indicators in the future:

- A consistent measure of visibility for both urban air basins and pristine regions.

- Statewide air levels and composition of PM2.5 (particulate matter with an aerodynamic diameter of 2.5 microns or smaller). This fraction of particulate matter can be inhaled most deeply in the lungs and likely represents a better indicator of potential human injury than the PM10 fraction that is currently collected.

- An understandable presentation of cancer risk based on regional exposure to toxic air contaminants. There are a number of considerations in the development of cancer risk estimates that need to be addressed to provide a full appreciation of this complex issue.

To support the development of future indicators on significant air quality issues, future efforts will focus on data collection and evaluation, as described below:

- Although a substantial amount of information has been generated for indoor air quality, there are no monitoring data for developing indicators that define the scope and magnitude of the problem. Indoor air quality is of particular concern because it may now present a greater threat to human health than outdoor air pollution.

- The development of the toxic air contaminant emission inventory indicator will facilitate the implementation of emission reductions from stationary sources and other area-wide sources.

- The development of community-based indicators for air quality will allow the identification of specific communities that are disproportionately exposed to higher levels of air pollutants.

- The development of population-based indicators will provide more meaningful information to the public about the number of people exposed to unhealthy levels of air pollutants.

Water

Water is one of California's most precious resources, serving a multitude of needs, including drinking, recreation, supporting aquatic life and habitat, and agricultural and industrial uses. It provides an essential lifeline for the state's burgeoning population of approximately 35 million. The management, assessment, and protection of California's water for all beneficial uses are of paramount concern for all of California's inhabitants.

Indicators were developed to track: (1) water quality, and (2) water use. Water quality indicators are presented according to the various beneficial uses of water resources. Such uses include drinking (and other household uses), crop irrigation, industrial and recreational uses, and fish and wildlife habitat. Water use indicators reflect trends in quantities of water used.

Water quality

The development of water quality indicators was limited by the quality of available data. For ambient waters, a sustained, comprehensive and consistent data collection effort has been lacking. To address this deficiency, the State Water Resources Control Board has instituted the Surface Water Ambient Monitoring Program (SWAMP) and the Groundwater Ambient Monitoring and Assessment (GAMA) Program. With the promise of these programs to reinforce monitoring and assessment activities, a more robust and complete set of indicators will become available in the future. Based on the best information currently available, the most significant findings of the water quality indicators are presented below:

- Sources of drinking water continue to show improvement in quality. Monitoring of about 20,000 sources shows that the number of exceedances of drinking water standards in 2000 was less than half of the value of the late 1980s. Since 1984, less than one percent of the 20,000 municipal drinking water sources in the state exceeded drinking water standards.

- The potential for groundwater contamination from leaking underground fuel tanks is declining. This progress is due to the cleanup of leaking sites and the upgrading of containment features of operating tanks. While leaking tanks still represent a widespread problem (there are about 17,000 sites in 2000), the number of sites has decreased by about 20 percent from 1995 to 2000. A small decline occurred in the number of leaking tanks within 1,000 feet of public drinking water sources.

- Coastal beach closures due to bacterial contamination increased 15 percent from 1999 to 2000. With the recent standardization of beach posting protocols, more consistent and meaningful trends will be available in the future.

- The number of sewage and petroleum spills and releases increased by about 33 percent from 1997 to 2000, from 1,445 to 1,918. The number of sewage spills alone increased by 76 percent.

- Data to present trends in surface water quality – in terms of the extent by which surface waters support beneficial uses (such as aquatic life protection and swimming) — are not available. A snapshot of the 2000 assessment is presented. Trends will result with implementation of new monitoring programs.

- Commercial shellfish growing waters continually meet the regulatory standard for fecal coliform bacteria during open harvesting periods.

- Only 12 percent of ocean waters, and 36 percent of bay and estuary waters have been assessed to determine the safety of consuming sport fish caught in these waters. These assessments show that the extent of ocean miles from which fish can be safely consumed once a week increased from 1990 to 1995, and remained the same in 2000. The extent of bay and estuary acres from which it is safe to eat fish once a week decreased in the same time period.

Water quality indicators under development are as follows:

- Leaking underground fuel tanks represent only a portion of the groundwater contamination problem. It is expected that a more complete picture of the number and extent of groundwater contamination sites, including contamination from leaking landfills and other unauthorized releases of contaminants to groundwater, will be addressed by future indicators.

- Beneficial uses of surface waters (lakes, rivers, etc.) will be assessed more extensively under a new program (SWAMP). These assessments will provide data for indicator development in the near future.

A possible area for indicator development in the future is the safety of eating fish caught from inland waters, as described below.

- To date, the inland waters assessed to determine the safety of consuming caught fish are a very small fraction of all waters where fishing occurs. A program similar to the Coastal Fish Contamination Program is needed to collect the data necessary to make this a useful indicator. Currently, this indicator can only be updated when special or one-time studies generate adequate data for assessment of rivers or lakes.

Water supply

- Urban uses of water are increasing; agricultural uses are leveling off. This change is primarily due to the increasing population and urbanization of agricultural lands.

- Recycling/reuse of municipal wastewater increased by 50 percent in 13 years. In 2000, the amount of recycled water was equivalent to the annual water supply needs of over 1,600,000 people.

Land, Waste and Materials Management

Waste is a by-product of human activity. If not managed properly, solid and hazardous wastes can exact considerable costs, in terms of lost resources, environmental contamination, and adverse effects on human and ecological health. Waste-related data are tracked by the California Integrated Waste Management Board (solid waste), and by the Department of Toxic Substances Control (hazardous waste). These data are collected under existing programs aimed at promoting waste reduction, recycling, diversion of solid waste from landfills, and waste management and remediation efforts to prevent or minimize environmental contamination and human exposures to hazardous chemicals. The indicators for waste show that:

- Although Californians are generating more solid waste, more of the waste is being diverted from disposal in landfills. Since 1989, the amount of solid wastes disposed of in landfills has decreased by about 13 percent. At the same time, diversion, which reflects recycling, reuse and waste reduction, has increased by over 500 percent. Much of the impetus for the diversion and recycling trends was provided by the Integrated Waste Management Act, which spurred the implementation of waste prevention, recycling and composting programs at the local level to meet goals for waste diversion that were established by statute.

- Similarly, waste tire disposal has been declining over the past decade, while diversion has been increasing. Approximately 23 million waste tires were diverted from disposal in 2000, more than double the number in 1990. Diversion appears to be influenced by the development of viable markets for waste tires, for such uses as fuels at cement kilns; use in asphalt for road construction; and pyrolysis (thermal degradation in the absence of oxygen) to produce oil, gas, and steel.

- The amount of hazardous waste generated and shipped for treatment or disposal over the past seven years has increased by 16 percent, from 2.3 million tons in 1993 to 2.7 million tons in 2000. However, when economic activity is taken into consideration, waste generation has declined by 30 percent.

- Disposal in landfills and recycling are the predominant fates of most hazardous waste shipments. In 2000, almost 40 percent of the shipments were destined for landfill disposal, and over 33 percent for recyclers. Both landfill disposal and recycling showed increases over the past seven years (65 percent and 19 percent, respectively).

- There are no clear trends for hazardous material incidents, for soil cleanups at hazardous waste sites, and for the number of contaminated sites.

- Information on the magnitude and scope of environmental contamination resulting from unsound management of solid and hazardous waste is very limited and fragmented.

Although data are now collected on the following, additional effort will be needed to develop meaningful indicators reflecting:

- Amounts of hazardous waste generated, segregated as federal hazardous wastes and non-federally regulated (commonly referred to as "California-only") hazardous waste. Currently, trends in hazardous waste generation in California cannot be compared with those in other states or the rest of the nation. California regulations are broader than federal law in defining what constitutes hazardous waste, such that certain wastes that would not be regulated as hazardous under federal law are regulated as such in California.

- Amounts of hazardous wastes exported by California to other states and nations, as well as the amounts imported into the state.

- Cleanups of illegal solid waste disposal sites and illegal tire sites.

Future efforts will attempt to address the following issues and indicators:

- Site contamination, including the movement of contaminants from soil to air or water, and the impacts of remediation efforts on environmental quality and reduction of potential risk.

- Quantifying the impacts of households on the overall solid and hazardous waste streams. Of particular interest are the generation and handling of household hazardous wastes, and the diversion of organic wastes from landfills through composting.

Pesticides

As hazardous substances that are deliberately introduced into the environment to achieve a desired outcome, pesticides represent a unique subset of environmental issues. Because of their inherent toxicity (they are designed to control or eradicate a target organism), pesticides have the potential to adversely impact human and ecological health. The data collection and environmental monitoring conducted by the Department of Pesticide Regulation (DPR) is used to determine whether the regulatory controls for a given pesticide need to be modified, or use of a pesticide prohibited, in order to prevent further environmental contamination and, ultimately, human exposures to pesticides at harmful levels. These data have provided the basis for the indicators presented in this report. The pesticide indicators show that:

- Since 1989, less than two percent of produce sampled contained illegal pesticide residues. In most cases, the residues found were for pesticides for which a regulatory standard ("tolerance") has not been established for the commodity in which it was found. Monitoring helps ensure that produce offered for sale complies with regulatory standards for pesticides in produce. Tracking pesticide residues is an important tool to enforce regulatory standards designed to prevent potentially harmful human exposures to pesticide residues.

- Reported illnesses related to occupational pesticide exposures declined by about 60 percent over the past decade, occurring less frequently in agricultural settings. The data on pesticide-related illnesses are from physicians, who are mandated by statute to report such occurrences, supplemented by DPR reviews of occupational illness reports in the state workers' compensation system.

- The presence of pesticides in groundwater can only be partially characterized at this time. The cumulative land area where pesticide use is regulated in order to protect groundwater has increased from 141 sections in 1998 to 459 sections in 2000. (A section of land is a one-square mile area, based on the U.S. Geological Survey Public Land Survey coordinate system.) However, this trend is largely driven by the extent of well monitoring conducted annually, and the regulatory response to the discovery of groundwater contamination, rather than actual environmental conditions. A second groundwater indicator, in two counties (Tulare and Fresno) that are vulnerable to groundwater contamination, shows a stable trend in the concentrations of simazine (a widely used pesticide in the area) and its breakdown products in a network of 70 domestic wells. This indicator, however, cannot be extrapolated to other areas or other pesticides.

- Limited information is available on the magnitude and scope of the impacts of pesticides on surface waters. Current surface water monitoring efforts for pesticides are only designed to characterize a particular site for a specific period of time, and these data are not generally suitable to track long-term trends.

- Available data on levels of pesticides designated as toxic air contaminants cannot be used as an indicator because there is no network of monitoring stations that sample pesticides over time. The data are from individual studies targeting a specific pesticide in areas of high use during periods of high use, and provide information in support of the possible identification of the pesticide as a toxic air contaminant.

- A meaningful indicator for pesticide use cannot be presented at this time. All agricultural pesticide use (defined broadly to include use on roadsides and other rights-of-way, parks, golf courses, and cemeteries) and structural use by professional pest control companies must be reported; however, institutional and home uses are exempt. Because aggregated use volumes in themselves only represent the potential for human health and environmental impacts, a more meaningful trend is desired. This type of information would require categorization of pesticides based on toxicity and environmental impacts, and then require integration of this information with use volumes.

- The adoption of reduced-risk pest management systems cannot be quantified at this time; however grant programs administered by DPR will provide a starting point for collection of this information.

- Data on the ecological impacts of pesticide use are limited only to fish and bird kills, and the reporting and maintenance patterns of these data sets are too fragmented to be incorporated into an environmental indicator.

Some of the areas to be explored in the future will focus on:

- Presenting data on all pesticide use (agricultural, institutional, home use and others) in terms of potential human health and ecological impacts. Work done by others (such as those described in *An Overview of Pesticide Impact Assessment Systems based on Indexing or Ranking Pesticides by Environmental Impact*, Cornell University, 1997; posted at www.cfe.cornell.edu/risk/pri/LCL-PestRiskInd7-97.pdf) in developing appropriate weighting factors (based on toxicity, environmental fate and transport, and other considerations) will be reviewed to investigate possible approaches in the development of an indicator. This will aid in tracking the reduction in potential human risks associated with the use of reduced-risk pesticides.

- Characterizing the impacts of pesticide use on water quality, including how urban use can affect water contamination. Much of the available data, and DPR's efforts, currently focus on areas of known or suspected contamination, typically in areas of heavy agriculture. Monitoring networks may be established for both surface water and groundwater to provide an ongoing, systematic data collection system that allows for improved assessment of water contamination by pesticides. Water contamination involving pesticides that are no longer registered for use falls under the responsibility of the State Water Resources Control Board (SWRCB). The identification of possible ways to integrate the data collected by DPR and SWRCB into an indicator reflecting overall water quality impacts of pesticides will be useful.

- Investigating possible options for collecting air monitoring data on a systematic, ongoing basis to support the development of a valid indicator for pesticide levels in air.

- Investigating pesticide use data for all agricultural and commercial structural pesticide applications along with data on emission potential as the basis for an indicator showing pesticides as sources of volatile organic compounds.

- Enhancing the indicator for pesticide-related illnesses. Because of consistent problems with physician reporting of non-occupational illnesses, DPR is working with the state's Poison Control Centers to develop a better means to track pesticide-related illnesses and injuries that occur in home and other non-occupational settings.

- Compiling and analyzing existing data on fish and bird kills, and exploring alternative means and data needs for tracking the ecological impacts of pesticide use.

Transboundary Issues

California is part of the global community sharing international borders with Mexico, and state boundaries with Oregon, Nevada, and Arizona. The movement of certain pollutants by natural processes, meteorological forces, and human activities can produce environmental threats which extend beyond California's geographical boundaries. Conversely, pollutants which originate in other states, countries or ecosystems, carried by atmospheric air currents, watersheds, trade, and travel can impact California. In this report, the transboundary issues include global climate change, stratospheric ozone depletion, pollution in the California/Mexico border region, and invasive species.

The greenhouse effect is a process that harnesses light reflected from the earth's surface and warms the atmosphere. A variety of both naturally occurring and synthetic greenhouse gases (GHGs), including carbon dioxide, methane and nitrous oxides, may enhance this effect. The National Research Council (NRC) climate change analysis requested by President George W. Bush and the Third Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) conclude that the global climate is changing at a rate unmatched in the past one thousand years. The IPCC assessment cites new and stronger evidence that most of the global warming observed over the last fifty years is attributable to human activities, and that anthropogenic climate change will persist for many centuries. However, while the NRC report generally agrees with the IPCC's Third Assessment, it does not rule out that some significant part of these changes is also a reflection of natural variability. The observed changes over the last fifty years and those projected for the future include sea level rise, higher maximum air temperatures, more hot days, fewer cold days, and greater extremes of drying and heavy rainfall. A more recent report from the NRC cites that periods of gradual change in the Earth's past were punctuated by episodes of abrupt change, including temperature changes of about 10 degrees Celsius, or 18 degrees Fahrenheit, in only a decade in some places. Greenhouse gas warming and other human alterations of the Earth's system may increase the possibility of large, abrupt, and unwelcome regional or global climatic events.

Environmental measures have been selected to help track certain parameters of climate change and GHG emissions as they relate to California. The global climate change indicators show that:

- Compared to the rest of the United States, California emits less of the greenhouse gas carbon dioxide, when calculated per person and per unit of the economy; however, compared with other developed nations, California emits more. Moreover, California's carbon dioxide emissions per person and per unit of gross state product have been declining in the past decade, despite increases in fuel use and population growth.

- Air temperatures have gone up by approximately 1 degree Fahrenheit (1°F) in rural areas of California over the past century, compared to an increase of about 3^0F in developed urban areas. Cities have higher temperatures than less populated locations because of the "urban heat island effect" which can skew temperature readings. Global air temperatures are estimated to have increased by 0.5°F to 1.0°F since the late 20th century.

- Snowmelt from the California Sierra Nevada has decreased by 9 to 12 percent over the past century. Lower water volumes of the spring snowmelt runoff may indicate warmer winter temperatures or unusually warm springtime temperatures.

- Sea level rise provides a physical measure of possible oceanic response to climate change. Over the last century, sea levels have risen at some points along the California coast, but decreased at others. Local land subsidence and, conversely, geologic uplifting of land mass can affect tidal calculations.

- The protective stratospheric ozone layer has gradually decreased over the mid-latitudes of the Northern Hemisphere (including California and the continental U.S.) from 1979 to the early 1990s. However, the downward trend has not continued in recent years as levels of ozone-depleting substances, including bromine and chlorine, stabilize in the stratosphere. Due to additional atmospheric processes that occur in the Polar Regions, ozone depletion in these regions is generally greater than over California.

The indicator for California/Baja California, Mexico border issues shows that:

- Air monitoring stations in the San Diego/Tijuana and Imperial Valley/Mexicali border areas reported peak ozone, carbon monoxide and particulate matter (PM10) concentrations that continue to exceed state air quality standards.

In the future, some of the efforts to address transboundary issues will investigate the areas described below as possible sources of data for indicators:

- Emissions of other greenhouse gases can be tracked based on statewide methane and nitrous oxide emissions data from the California Energy Commission's greenhouse gas inventory report, which is expected to be released in 2002.

- The Pacific Ocean plays a role in determining California's onshore air temperatures through the eastward movement of air masses, which have been affected by ocean water temperatures. Air temperature data from an array of land weather reporting stations and sea surface temperatures off the California coast can be correlated to reflect the ocean's influence on calculations of climate change.

- Additional climate change indicators to be explored include trends in soil moisture, precipitation intensity, windiness, sea wave height and intensity, Pacific Ocean current patterns, and changes in plant blooming cycles (such as those of the lilac and honeysuckle) and in animal and insect migrations.

- California emissions of hydrochlorofluorocarbons (HCFCs) for ozone depletion and hydrofluorocarbons (HFCs) for global warming can be estimated from an emissions inventory of reported substances.

- The SWRCB monitors water from the Tijuana River, which flows northward from Tijuana into San Diego, and the New River, which flows northward from Mexicali into Calexico and the Salton Sea, for pathogens and pollutants. Less than one-quarter of the total flows in these rivers is related to sewage outflows, but much of it is untreated. New sewage treatment plants are being constructed to address this problem. Additional contaminants enter the river from agricultural returns. Indicators based on these monitoring data will track the progress of the river cleanup efforts.

- The suitability of data on the movement of hazardous wastes across the border will be investigated for potential indicator development. Hazardous wastes are transported to and from California either as usable "products," or as wastes destined for treatment or disposal. At the border crossing, the number of trucks carrying waste is tallied daily, and monthly random truck inspections are conducted at Tijuana, Otay Mesa, and Mexicali. The hazardous wastes are most commonly generated from the textile, metal plating, and electronic industries.

- At present, there is a 90 percent rate of compliance with regulatory requirements for mid-ocean exchange of ballast water by ships entering California ports. Although the exchange will decrease the likelihood of non-indigenous aquatic species entering California waters, the efficacy of the ballast water transfer, species characterization, and the role of bottom paint on the hull of vessels are being studied.

Human Health

The health of Californians is generally very good and improving, in terms of longevity and quality of life. Infant mortality rates continue to decrease, from almost 8 deaths per 1,000 live births in 1990 to slightly more than 5 deaths per 1,000 live births in 1999. The life expectancy of Californians continues to increase, and compares favorably to national averages. In 1997, life expectancy at birth was 75.5 years for males and 80.7 years for females in California, compared to 73.6 years for males and 79.4 years for females nationally. However, certain health conditions, including asthma, have been reported to be increasing in frequency over the course of the years, for reasons not yet well understood.

Cal/EPA programs aim to control the presence of harmful chemicals in the environment, and to ensure that sensitive or highly exposed groups are protected from exposures that may lead to adverse health effects. Protecting human health is the underlying basis for many regulatory environmental standards. Hence, many of the indicators in the other sections of the report relate to human health. The indicators in the human health section are those that reflect the impacts of exposures to environmental contaminants on people. These indicators will assist Cal/EPA in understanding how its efforts to protect the public from environmental pollutants are influencing human health. One indicator which can directly be attributable to environmental pollution is the presence of lead in children's blood at elevated levels (10 micrograms per deciliter or higher). Humans can retain, or bioaccumulate, chemicals in their bodies over time. These chemicals can have delayed adverse effects, and thus represent a potential health threat. Currently, lead is the only bioaccumulated substance for which levels in children are reported to the state, when they exceed the standard. Presently, only two facilities report blood lead levels for all children tested. However, these data are not necessarily representative of blood lead levels in the California population; thus no trends can be presented.

Future efforts related to developing these indicators are described below:

- Potential bioaccumulative chemicals that need to be addressed with indicators include persistent organic pollutants and inorganic chemicals such as lead and mercury.

- Environmental pollutants are known to influence the disease process, yet their impacts on human health are difficult to quantify. Besides environmental exposures to pollutants, many factors influence the disease process, including genetics, lifestyle choices and aging. All of these contribute to specific human health conditions and diseases, making the development of human health indicators of environmentally-related effects challenging.

- More monitoring data on human disease conditions that may be related to environmental contaminants are needed. Many diseases and conditions are monitored through programs of other agencies and related entities. However, it is not always clear from the available data whether occurrences of adverse health effects are related to exposure to environmental chemicals. Careful surveillance of disease conditions may lead to a better understanding of environmental influences. Recently enacted legislation (Senate Bill 702, Chapter 538, Statutes of 2001) requires a study on the feasibility of developing an environmental health surveillance system for the state. Specific research is needed to better characterize environmental contributions to existing disease rates.

There is always the possibility that some diseases and conditions affected by environmental contamination go unnoticed or are difficult to quantify. With advancements in medical science, environmental associations with disease will be better understood. Cal/EPA programs will use this knowledge in continued efforts to minimize human exposures to potentially harmful pollutants.

Ecosystem Health

Protection of the environment and natural resources is the focus of much of the work at Cal/EPA and the Resources Agency. The primary issues facing these agencies are preserving adequate quantity and quality of habitat, biodiversity, and ecosystem function, while making use of California's abundant and unique natural resources. There are relatively few data sets available for developing indicators of ecosystem health. In many instances, the data needed to support the development of the indicators in this area are in the process of being collected, are collected in an incomplete manner, or are not collected at all. At this time, limited conclusions about the health of the state's ecosystems can be drawn from the available data.

Quality and quantity of habitat

There is significant pressure for the conversion of natural landscapes to more human-oriented uses, such as irrigated agriculture and residential uses. It has long been recognized that degradation of habitat, including fragmentation into small, disconnected pieces, is a key factor in the reduction of ecosystem integrity. Some ecosystems are more sensitive than others and ecosystems in certain regions of the state have greater environmental value than others. The indicators in this report suggest the following:

- An average of 45,000 acres per year are being converted from farmland and rangeland to urban and other uses. Agricultural land falls into the "working landscape" category, preserving varying degrees of ecological value, providing open space, and providing crucial capital for agriculture.

- In the past 15 years, about 1.1 million acres of the 1982 base acreage of forest and rangeland have been converted to other uses. These lands also fall into the working landscape category, but often have a higher degree of ecological integrity than farmland.

- Nineteen percent of California lands are managed to maintain a high degree of ecological integrity, such as parks. An additional 64 percent are working lands which, while managed for some degree of production, continue to provide important wildlife habitat. The remaining lands have been significantly transformed by human activities.

Biodiversity

The indicators for the diversity and abundance of California's plants and animals show the following:

- Little is known about the status of populations of threatened and endangered species (TES). Fewer than 5 percent of threatened and endangered plant species, and about 15 percent of animal species have increasing populations. The population trends for about 20 percent of TES plants and 35 percent of animals are unknown.

- The population of winter- and spring-run chinook salmon in the Central Valley, one of the TES for which reasonably good information exists, continues to decline to very low levels.

- The population of the least tern, a coastal shorebird, appears to be stable at present.

- The population of the threatened desert tortoise is decreasing, suggesting that human activities continue to have a negative impact on the species.

- In two important forested areas that cover the Sierra and Cascade mountain ranges along the eastern portion of the state, the extent of both hardwood and conifer tree canopy has increased.

- The population of the Northern Spotted Owl along the north coast appears to be holding steady at 2,300 breeding pairs. Future reports will include an assessment of the status of California spotted owl populations in various regions of the state.

Ecosystem Function

Developing indicators for ecosystem function was a challenging endeavor. Identifying the appropriate measures of ecosystem function is difficult, and once identified, finding data to support the indicator has proven nearly impossible.

- In this first report, a single measure of ecosystem function is presented – the clarity of Lake Tahoe. Lake clarity, a measure of eutrophication or nutrient loading and sedimentation, reflects many processes that occur within a lake system. One of the reasons that it is an excellent indicator is that it captures multiple ecological processes of the lake, therefore reflecting significance beyond the simple measurement of clarity. The decrease in clarity of Lake Tahoe over the past 30 years suggests that the healthy ecological functions in this lake are declining. Information on additional lakes in different regions of the state will be investigated for future reports.

- The Stream Invertebrate Bioassessment Program, a joint effort of the California Department of Fish and Game and the U.S. Environmental Protection Agency, will provide information on the health of streams throughout the state. Measurements of the abundance and diversity of benthic invertebrates living in the streambed broadly reflect the status of a variety of ecological processes within each stream.

- There is a need for additional information on the status of natural resources for all California ecosystems. Most data collection efforts to date have been reactive, focusing on "hot-spots" such as spills of toxic chemicals, reports of fish kills, effects of building a new road, or other specifically targeted activities. In order to develop indicators that reflect the status and trend of the state's ecosystems, scientifically-based monitoring is needed. Without such monitoring data, more accurate and inclusive indicators cannot be developed.

In some areas, little if any information is presently available for indicator development. These are identified as Type III indicators or data gaps:

- While frog deformities and deaths have been documented throughout the nation, scant information is available on the status of amphibian populations in California.

- Significant national efforts are underway at the U.S. Environmental Protection Agency and elsewhere to understand the effects of endocrine disrupting chemicals on wildlife. In particular, treated wastewater has been shown to cause harmful effects on fish, including salmon. Information on the presence of such chemicals in California's waters needs to be collected.

- Data on non-native invasive species in specific ecosystems are needed. This issue is also addressed in the "Transboundary Issues" section.

- Persistent organic pollutants, known to cause reproductive harm and cancer, have been found in marine mammals throughout the world. These organic pollutants include pesticides and industrial chemicals that have been banned for many years, as well as emerging problem chemicals. Monitoring of seals, as suggested by the "persistent organic pollutant in harbor seals" indicator in this report, could signal the presence of problematic levels of such chemicals in aquatic ecosystems.

- Data on agricultural ecosystems are presently available, but coordination with other state agencies with agricultural expertise is needed to develop information in a form useful for indicators. Agriculture faces significant challenges, including falling commodities prices, increased global competition, and increasing demands for water and land by a growing urban population. Agriculture has played an important economic and historical role in California, and in many cases, there are positive environmental benefits within agricultural land use practices. Development of indicators of agroecosystem health will be a focus of future reports.

- Urban ecosystem indicators are also sparse in the report. Similar to agro-ecosystem indicators, partnerships need to be formed to develop appropriate indicators in this area. One of the future challenges is to identify and develop measures of urban habitat sustainability and quality of life.

What direction should the development of ecological indicators take in the future? How can these efforts be combined with those of others to better characterize the state's ecosystem health, and this information used to allocate resources and develop policy on natural resource and environmental protection? Efforts in the following areas will help address these questions.

- A regionally-based and statistically-robust program of long-term ecosystem monitoring is needed. This effort could focus on identifying particularly sensitive ecological areas. The Nature Conservancy has already taken initial steps in this effort. A network of representatives from the Resources Agency, Cal/EPA, federal agencies, and non-government organizations could meet periodically to coordinate efforts and help identify ecosystem monitoring priorities. Such an effort might be done in collaboration with the California Legacy Project at the Resources Agency.

- The Organisation for Economic Co-operation and Development has proposed the development of a natural capital index for biodiversity. This measurement integrates information on habitat quality, quantity, and species richness and abundance. If specific information is not available on the population status of a species, which is the case for many threatened and endangered species in California, data on ecosystem pressures can be substituted. The feasibility and value of such an index for California will be explored in the future.

- Although this report contains significant information on the extent of forest and rangelands, the relationship between these indicators and wildlife biodiversity is not clear. Future efforts will explore the feasibility of developing such an indicator.

- An obvious omission in the ecosystem health indicators is the lack of an indicator for the status of wetlands and marine resources. The Bay Institute of San Francisco (www.bay.org), the San Francisco Estuary Program (www.sfei.org), and Western Center for Estuarine Ecological Indicators at Bodega Bay Marine Labs are working on developing indicators for the Bay Delta, its watershed, and the estuary.

- There is a need for analysis of changes in habitat quantity across the state for all ecosystems. Without a quantitative assessment, decisions will be based on incomplete and potential incorrect information. This is one of the goals of the California Legacy Program.

Future Directions for the EPIC Project

The EPIC Project is intended as a continuing effort to produce and maintain an environmental indicator system for California that conveys meaningful information about key environmental issues in the state, and that serves a critical role in the decision-making processes in environmental programs. The initial set of indicators serves as the starting point for the EPIC Project's efforts to evaluate, validate, enhance and expand California's environmental indicator system. As part of its future efforts, the EPIC Project will:

FINDINGS

- Enhance collaborations with the Resources Agency, the Department of Health Services, and other entities in order to develop a more integrated and coherent environmental reporting mechanism for the state.
- Review the existing issues to ensure that all pertinent areas are covered. The review will focus both on the issues themselves and what they cover, as well as new areas not currently included. Possible areas of expansion include issues dealing with environmental policies, such as sustainability, environmental justice, and pollution prevention.
- Explore alternative ways of organizing the issues so that the interrelationships among them are more evident. Presently, issues have been largely defined based on areas of regulatory responsibility (e.g., air pollution, water quality and others). A better understanding of the interrelationships may improve the formulation of solutions to environmental problems, and promote more coordinated monitoring and data collection.
- Use geographic information systems (GIS) to analyze and present different types of information for a defined geographic area. GIS is a computer-based tool for managing and presenting multiple geographically-based data, providing new perspectives and understanding on environmental and natural resource issues.
- Develop regional indicators, where needed to convey more meaningful information about environmental conditions.
- Improve existing indicators based on new scientific knowledge, analytical capabilities, or regulatory changes, and update indicators as new data become available. The EPIC report will be published on a regular basis (every two years, or as necessary).
- Work with those responsible for strategic planning, policy formulation and budgeting to assess and enhance the utility of the indicators in decision-making. By evaluating and characterizing the factors that can influence the trends in an environmental indicator, the impact of environmental programs in effecting a desired change in an indicator can be better understood.
- Coordinate with the Emerging Environmental Challenges Program in the Office of Environmental Health Hazard Assessment to explore ways by which the environmental indicators can be used to identify and characterize future environmental challenges and, conversely, develop appropriate indicators for issues that have been identified as emerging challenges.
- Strengthen and expand partnerships with those who have an interest in California's environment, including local government agencies, community organizations and the regulated community, in working toward sustainability goals. These partnerships will facilitate the sharing of data, information and resources, and promote the setting of shared goals and priorities.
- Promote public awareness of environmental issues using indicators as tools for communicating information, and initiate dialogue with interested parties to invite input. This will be accomplished by convening regional meetings, publishing materials geared to a broad audience with information drawn from this report, and popularizing the EPIC web site (www.oehha.ca.gov) which will include links to data sources, and electronic mailing lists.

The EPIC Project is an aggressive undertaking to better understand what is happening in the environment in order to find effective ways of preserving and improving it. This undertaking is still in its formative stage. The process for identifying and developing indicators has been established, and an initial set of indicators presented, but much work remains to be done. In the end, pursuing the development of meaningful, well-founded environmental indicators will yield substantial rewards for California by optimizing the efforts of its environmental and natural resource programs.

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APPENDIX A

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The task of identifying, selecting and developing the initial set of indicators was carried out by seven subgroups: air quality; water; land, waste and materials management; human health; ecosystem health; pesticides; and transboundary issues. The following individuals participated in, or provided input into the work of the subgroups:

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Types of Indicators Used to Assess an Organization's Performance

Mission-Based indicators:

Direct or indirect measures that can be used to assess status and trends associated with the agency's mission. Cal/EPA's "mission-based indicators" are environmental indicators.

Policy indicators:

Direct or indirect measures of either mission-based or program achievements that can be used to assess the status and trends in the accomplishment of an environmental result set in a broader social, economic, cultural and political context, and that cuts across multiple mission-based issue areas. Examples include indicators relating to environmental justice, sustainability, and pollution prevention.

Program performance indicators:

Direct or indirect measures of the achievement of the intended purpose of a program, expressed as either an environmental result or a program result. Examples include number of hazardous waste sites under remediation, number of children tested for blood lead levels, number of pesticide containers recycled, and number of endangered species delisted.

Program activity and efficiency indicators:

Measures that document the level of activity or efficiency of a program. Examples include cost per permit issued, average time to process a permit, and number of participants in pollution prevention programs.

Administrative indicators:

Measures that document the effectiveness and efficiency of the functioning of the organization itself. Examples include personnel turnover and vacancy rates, and degree status of professional staff.

Reference:

Florida State University/U.S. Environmental Protection Agency, Office of Pollution Prevention, Pesticides and Toxic Substances. *Chemical and Pesticides Results Measures*, January 2001. Posted at: www.pepps.fsu.edu/CAPRM/index.html

EPIC Glossary

Environmental indicators:
Measures that present scientifically based information on environmental conditions (e.g., public and ecological health), trends, and their significance. An indicator has a significance extending beyond that directly associated with the parameter measured. Examples of previously reported indicators include: ozone concentrations in air, blood lead levels in children, amount of solid waste disposed of in landfills, and pesticide residue levels in food.

Goal:
A desired result that Cal/EPA is working to achieve and are environmentally broad in scope.

Index:
A set of aggregated or weighted parameters or indicators.

Indicator suite:
A group of indicators that collectively present information on major environmental issues, such as climate change, toxic contamination, biological diversity, hazardous waste, pesticides, ecosystem health, and use of natural resources (energy, fisheries, forests, public lands, soil and water).

Integrative Indicator:
An indicator which captures multiple aspects of a given issue or system in such a way that its significance extends beyond the measure(s) from which it is derived to a greater degree than other available indicators.

Issue:
A topic of environmental concern to California, including its components or dimensions, or sub-issues, such as climate change, toxic contamination, biological diversity, hazardous waste, pesticides, ecosystem health, and use of natural resources (energy, fisheries, forests, public lands, soil and water).

Issue structure:
A framework for organizing issues relevant to an organization into issue categories, and their corresponding issues (and sub-issues).

Measure:
Raw or analyzed data obtained from monitoring, surveys and other valid data collection methods. Measures form the basis for environmental indicators.

Parameter:
A property (e.g., pollutant concentration, pollutant discharge quantities, chemical body burden, etc.) that is measured or observed.

Qualification standards:
A set of criteria that define an acceptable indicator, designed to ensure that candidate indicators are appropriate for the indicator system in question. Examples of qualification standards include relevance to the mission of an organization, geographic scope, quality of data, and type of information provided by the indicator (e.g., environmental, program performance or administrative).

Selection criteria:
A set of criteria designed to ensure the quality and consistency of indicators included in an indicator system. Examples of selection criteria include measurability, data quality, representativeness, ability to support decision-making, and cost effectiveness.

Sub-issue:
The components or dimensions of an issue. Sub-issues help in identifying potential indicators for an issue.